

Spring 1983

AN ECONOMETRIC ANALYSIS OF US FARMLAND PRICES, 1941 TO 1980 (UNITED STATES)

DANIEL LEE DUNN
University of New Hampshire, Durham

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AN ECONOMETRIC ANALYSIS OF
U.S. FARMLAND PRICES, 1941 to 1980

BY

Daniel Lee Dunn
B.A., Westfield State College, 1978

DISSERTATION

Submitted to the University of New Hampshire
in Partial Fulfillment of
the Requirements for the Degree of

Doctor of Philosophy
in
Economics

May, 1983

This dissertation has been examined and approved.

Bruce E. Lindsay

Dissertation director, Bruce E. Lindsay
Associate Professor of Resource Economics

Edmund F. Jansen, Jr.

Edmund F. Jansen, Jr., Professor of
Resource Economics

Richard L. Mills

Richard L. Mills, Associate Professor of
Economics and Business Administration

Allen R. Thompson

Allen R. Thompson, Associate Professor of
Economics

Theodore E. Howard

Theodore E. Howard, Assistant Professor of
Forest Economics

May 3, 1983

Date

ACKNOWLEDGEMENTS

Special thanks to the following: to my parents, Alfred and Delores Dunn, and family who have provided me with inspiration and encouragement in my studies; to my friends whose camaraderie has made the survival of graduate school and the dissertation process bearable; and to the members of my dissertation committee, in particular Bruce Lindsay whose guidance, support and friendship gave direction to my graduate work and made its completion possible.

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ABSTRACT

AN ECONOMETRIC ANALYSIS OF U.S. FARMLAND PRICES, 1941 to 1980

by

DANIEL LEE DUNN

University of New Hampshire, May, 1983

The Abstract

The value of farmland in the United States comprises approximately seventy-five percent of the total value of farm assets. U.S. farmland prices have risen steadily since 1940. The period of 1970 to 1980, however, exhibits an increased rate of growth in average farmland values.

Rapid farmland price inflation could have implications for the structure of the American farming sector. An increase in the concentration of control of farm production assets, the raising of barriers to entry into agriculture and pressures on rural farm financial institutions from increased leveraging of farm loans may all result from increasing farmland values.

Previous research on farmland prices suffers from a number of deficiencies, including: 1) the lack of stability of models; 2) the exclusion of relevant variables; 3) the use of single equation estimation techniques; and 4) the inability to accurately forecast current farmland price movements. The purpose of this study was to overcome the problems of earlier analyses. Explicitly, a three equation model of farmland prices was developed. Hypotheses of different factors influencing farmland prices over the period 1941 to 1980 were tested and significant factors identified. Farmland price forecasts were generated using the three equation model and two univariate ARIMA models estimated in a Box-Jenkins context. Comparisons of forecasts were made based on relevant criteria.

CHAPTER ONE

INTRODUCTION

Prior to the late 1940's, movements in farmland prices closely paralleled those in farm income. Researchers claimed current and future streams of income as the sole determinant of average farmland values. However, steady land value increases occurring with decreasing or stable levels of current farm income into the 1950's stimulated research examining the possibility of factors other than farm income affecting farmland prices.

Initial investigations [Larsen (1948), Nowell (1947), Scofield (1957), Scofield (1965) and Chryst (1965)] into the divergence of farmland price changes from movements in farm income levels, found non-income factors, such as productivity, interest rates, price and income supports, credit availability, and demand for land for non-agricultural use, significant in explaining average farmland values. Further research [Herdt and Cochrane (1966), Tweeten and Martin (1966) and Reynolds and Timmons (1969)] provided support for this premise. Land price forecasting models, in addition to models developed to

obtain structural estimates, were introduced during this period.

In the 1970's, research on U.S. farmland prices increased in response to the rapid rise in the value of agricultural land over the decade. Additional factors, such as capital gains and general price inflation, were hypothesized to affect farmland price movements. A study by Pope, et. al. (1979), which evaluates past research efforts and some current analyses [Melichar (1979), Reinsel and Reinsel (1979), Plaxico (1979) and Kuhlman (1979)] point to the need for: (1) improved forecasting models to supplement present studies, (2) more relevant analyses of factors influencing farmland prices and (3) analyses of how the nature of these influences are changing.

This study develops a model of U.S. farmland prices. The farmland price model consists of three equations, a farmland price equation, a net farm income specification and an agricultural exports equation. In addition, a univariate model is developed to forecast farmland prices. Average farmland values are forecast and comparisons of predictive ability made based on relevant criteria discussed below. Annual data for the period 1941 to 1980 are used for estimation of the models. The forty-eight contiguous states are the unit of analysis.

The remainder of this thesis is structured as follows. The second chapter describes the problems stemming from rapid land price inflation and the objectives of this study. The third chapter contains a literature review. A description of the models and methodology to be employed is found in Chapter Four. Chapter Five contains the estimated models and a discussion of the results. Chapter Six provides a description of the forecasting procedure and an evaluation of actual forecasting results. The final chapter, Chapter Seven, summarizes the study, offers conclusions, suggests policy alternatives and proposes directions for further research.

CHAPTER TWO

PROBLEM IDENTIFICATION AND DETAILED PURPOSE

The value of farmland in the United States comprises approximately seventy-five percent of the total value of farm assets [1]. Regionally, this figure ranges from sixty-five percent in the Lake States production region to eighty-nine percent in the Pacific States production region [2]. Farm real estate is also currently the most price-sensitive long-term asset in agriculture [3]. It is shown below that sharp movements in farmland prices may have profound effects on the farm sector.

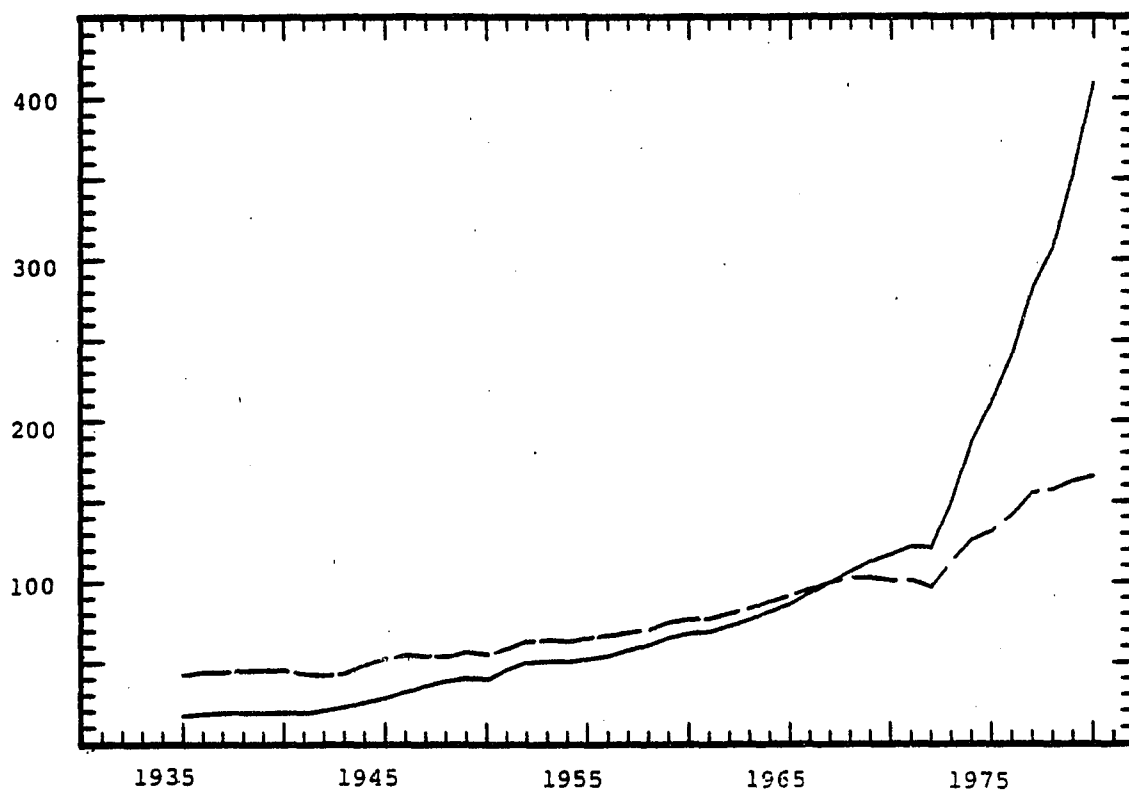
Since 1940, American farmland prices have risen steadily in each region. At the national level, the average nominal value of an acre of farmland has grown at an annual compound rate of eight percent over this period [4]. Figure 2-1 shows the nominal and real average values per acre of U.S. farmland from 1935 to 1980. Figure 2-2 charts the percentage change in nominal and deflated farmland values from the previous year.

FIGURE 2-1

Nominal and Real Indices of Average Farmland
Values, United States, 1935 to 1980

Nominal Index _____
Real Index - - - - -

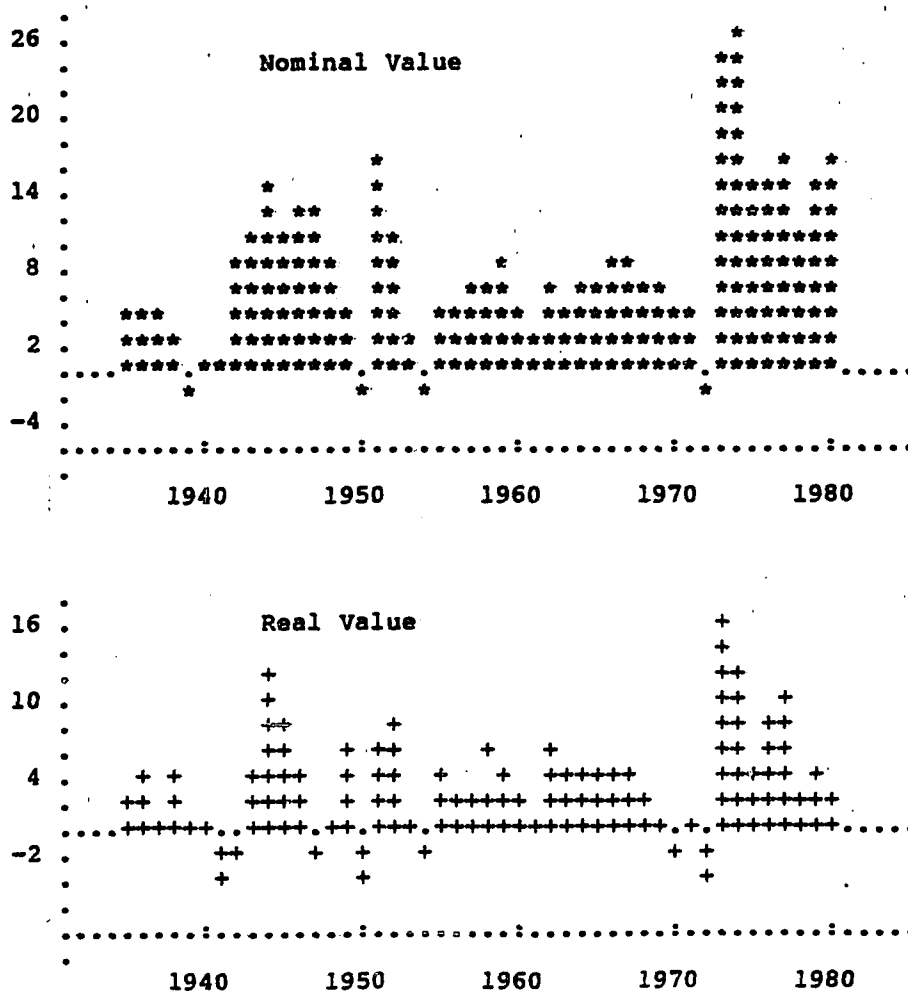
1967 = 100



The real index of farmland prices is the nominal index deflated by the GNP price deflator. Sources: Farm Real Estate Market Developments, various years and The Economic Report of the President, 1981.

FIGURE 2-2

Percentage Change in Nominal and Real
Average U.S. Farmland Values per Acre



The real index of farmland prices is the nominal index deflated by the GNP price deflator. Sources: Farm Real Estate Market Developments, various years and The Economic Report of the President, 1981.

The growth experienced in farm real estate prices is evident. The period from 1935 to 1970 exhibits a steady rise in average farm real estate values. The most recent decade, however, shows a dramatic increase. Nominal agricultural land prices have grown at a compounded rate of 13 percent annually from March, 1970 to February, 1980. This growth rate in farmland prices is above the eight percent annual compounded rate of general price inflation over the period [5].

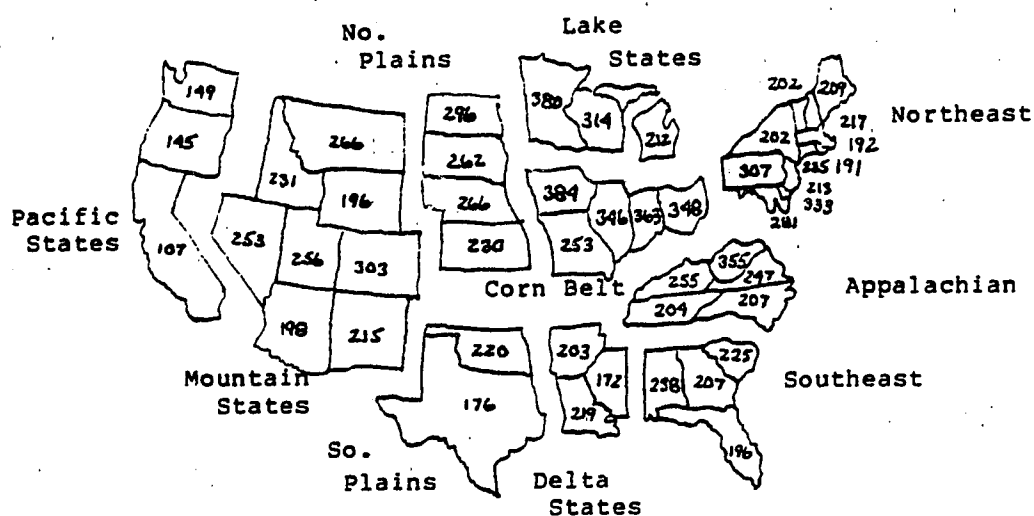
The increase in average farmland values can also be seen at the regional level. Figure 2-3 shows the total percentage increase in the average value of farm real estate per acre from 1970 to 1980 for each state. March 1980 farmland values per acre in the United States averaged more than three and one half times their level in 1970 [6].

The Problem

Possible effects of rapidly rising farmland prices on the farm sector and rural farm communities are offered below. These effects may be placed in two categories: 1) the influence of land price inflation on farm ownership, through the increase in concentration of control of farm production assets; the raising of barriers to entry into agriculture; and the increase in non-operator, absentee ownership of farmland; and 2) the effects of land price inflation on rural farm financial institutions.

FIGURE 2-3

The Percentage Change in the USDA Nominal Index of Farmland Prices, 1970 to 1980, for each State, Grouped by Production Region



Source: Farm Real Estate Market Developments, August, 1981.

Farm Ownership Implications-

The ownership structure in U.S. agriculture is often a topic for discussion by agricultural economists and farm groups. The government has long made preservation of a family farm structure in U.S. agriculture a goal of farm policy [7]. Many argue the benefits of a structure composed of small to medium family farm operations, based on the issues of income and wealth distribution, control of the food supply and the well-being of rural farm communities [Stanton (1978), Boles and Rupnow (1979), Reinsel and Reinsel (1979), Carter and Johnston (1978), Plaxico (1979) and U.S. GAO (1980)]. There has been a case made for the promotion of a small to medium sized family farm structure in U.S. agriculture.

Increasing concentration of farm ownership in the U.S. is occurring. The decrease in the total number of farms and the increase in the average size of a farm in the U.S. is consistent with this. The total number of farms decreased by 42 percent between 1960 and 1979 and 22 percent between 1970 and 1979 [8]. The average size of a farm increased by 60 percent and 27 percent over the two time periods, respectively [9]. The concentration of ownership can also be viewed in terms of total farm revenues. In 1961, the top three percent of farm firms, ranked by sales, accounted for approximately 20 percent of total farm cash receipts. In 1979, the top two percent of all farms had 37 percent of the sales and controlled 14 percent of the land [10]. The

introduction of more land intensive technologies during this period and decreasing net margins per unit of production have been suggested among other influences as being important in explaining the increase in concentration in farming [Carter and Johnston (1978) and U.S. GAC (1980)]. The rise in farm real estate prices may also be a prime factor.

The growth in farm real estate prices has resulted in an increase in the total value of farm assets. Owners of farmland have generally benefitted from the increase, particularly large established owner-operators and landlords. Large scale owners of agricultural land not only achieve substantial realized and unrealized capital gains with farmland price increases, they are also placed in a more advantageous position to expand. Rising real estate values provide increased collateral for expansion loans, while the returns from other landholdings and higher equity position can provide cash for the first years of a mortgage. It is more difficult for new farmers or small-scale operators to bid on farmland due to their lower relative equity position and cash flow situation. Given current farm policies and land price inflation, increased concentration of farm real estate assets in the hands of large-scale owner-operators and landlords could continue.

In contrast to benefitting larger landowners, rapid land price inflation has substantially raised entry costs to prospective farmers. It is also more difficult for new farmers to bid on farmland relative to large established landowners, as discussed above. The large land investment in a beginning farm operation, the lower relative equity position of new farmers and the smaller returns in the earlier years of a mortgage present barriers to those wishing to enter agriculture. Farm real estate has been likened to a "growth stock," best and most easily owned by those who can weather its low current return in the first years after purchase [Melichar (1979)]. Established farmers, with the ability to tolerate the initial current return on the additional investment, have the increased potential to enlarge their landholdings. Entry into agriculture becomes more difficult with rapidly rising farmland values.

Besides concentration of farm ownership and higher barriers to entry into farming, a possible result of, and factor behind, rapidly rising farmland prices is the increased speculation in farm real estate. Speculators see farmland as a store of value and a means to diversify their portfolios. Farmland markets in the past have compared favorably with stocks as an investment alternative. During the 1960's and 1970's, farmland price appreciation outpaced gains in the stock market [Kost (1968) and Healy and Short (1978)]. Farm real estate is also viewed as a successful

hedge against inflation. U.S. agricultural land prices, as mentioned, have grown at an annual compound rate of more than five percent above general price inflation since 1970. In addition, the purchase of farmland is seen as a lower risk investment [Robichek, et. al. (1978) and Feldstein (1980)]. The expectations for farmland prices to continue upward may have fueled further land price increases and made farmland an attractive investment for both farmers and non-farmers.

A result of the purchase of agricultural land primarily as a store of value is that productive farmland comes under absentee, non-operator, or other non-farmer ownership. The percentage of farm real estate transfers where the purchasers were in the non-farmer category has fluctuated between 30 and 40 percent of all transfers for the period 1960 to 1980. This figure was 30 percent for 1980 [11]. Of the people who owned farm and ranchland in 1979, only 25 percent were classified as farmers by the USDA. It is estimated that non-farmers may own as much as 50 percent of all farmland [12]. In recent times farmland has also been purchased by foreign investors [13].

Increased concentration of non-farmer ownership of agricultural land has been viewed as a problem by many, particularly for rural farm communities [Boles and Rupnow (1979)]. Most times the land remains in agricultural use, but often operated by farm management firms, tenants and

renters. Three effects of non-operator, absentee and large corporate agri-firm land ownership were offered by P.M. Raup [Boles and Rupnow (1979)]. Raup, in testifying before a congressional committee, suggested the effects of absentee ownership would be: " 1) rural population decline, which would lead to a declining rural social and economic structure; 2) decline in levels of age, education and residential stability, adding to the destruction of social-political-economic systems in rural areas; and 3) a rise in absentee-owned farms, which would take profits generated by these farms out of the local community." [14].

Implications for Rural Farm Financial Institutions

The rate of farmland price appreciation of the past decade may have also contributed to farm firms being increasingly leveraged. The percentage of credit financed farmland transfers of total farm real estate transfers has risen from 44 percent in 1944 to 90 percent in 1979, with the ratio of debt to purchase price rising from 58 to 79 percent [15]. Melichar (1977) suggested the increased debt may be concentrated primarily among those who have significantly expanded their operations. He stated the recent capital spending and land price boom has been debt financed to a level not seen since 1920. This situation leaves small rural banks heavily involved in farm loans in a precarious position.

As mentioned above, land price inflation has provided additional equity to collateralize farm real estate loans. Farmland purchasers made small initial down payments and let land price inflation appreciate their property values. The landowners then borrowed more against the increased value for the next land deal, and so on. This process works as long as: (1) farmland prices continue to rise at high rates, (2) mortgage rates remain stable and at reasonable levels, and (3) farm income trends remain favorable. Increased leveraging has created an ownership structure dependent upon further land price increases and favorable current returns to farming. The ability of farmland owners to meet loan repayments and farm income to generate deposits links the banks to this situation.

The possibility of land price declines, poor income years, or changes in farm policy unfavorable to large-scale borrowers or farmland capital gains exists. During 1981, unlike the rapid rise of the previous decade, farmland prices fluctuated, with a general decline in the fourth quarter. The index of U.S. average farmland values per acre increased by one percent in 1981 [16]. This, coupled with soaring costs and stable or declining crop and livestock prices, which leaves real net farm income at near-depression levels, has resulted in severe problems for excessively leveraged farmers and their creditors [17]. Fifteen percent of the nation's banks hold more than half their lendings in the farm loan category [Melichar (1977)].

Widespread defaulting of major borrowers on farm real estate debt could result in the failure of many small rural banks.

Some of the problems that may be related to rapidly rising farmland prices were outlined above. These problems could alter the income and wealth distributions within agriculture and between the farming sector and other sectors of the economy. Food prices, agricultural employment patterns, the cost of agricultural production, the preservation of farmland, the land ownership structure, access to agriculture as an occupation and rural-farm communities themselves could all be effected.

Many would argue that the rapid increases witnessed in farmland prices are an ingredient behind the economic situation in which American agriculture finds itself. It is evident that agricultural producers, those influencing farm policy, and producers in industries strongly linked to the farm sector would benefit from information concerning farmland price behavior and accurate forecasts of farmland prices.

Objectives

Previous research on farmland prices suffers from a number of deficiencies, including: 1) the lack of stability of models when re-estimated outside of their initial sample periods; 2) the exclusion of variables in the models, such as agricultural exports, alternative investment returns and real capital gains, which may be important in explaining

current farmland price behavior; 3) the use of single equation techniques in modelling farmland prices, which assume away the existence of simultaneous equation bias; and 4) the inability of previous models to accurately forecast farmland prices. These earlier models are discussed in Chapter Three.

The purpose of this study is to overcome the problems of earlier analyses. Explicitly, the objectives are: 1) test the hypotheses of different factors influencing farmland prices over the period 1941 to 1980; 2) identify the significant factors and interpret their relationship to farmland price behavior; 3) provide improved farmland price forecasts of different lengths; and 4) suggest policy alternatives, with estimation and forecasting results in mind, focusing on policies which could dampen farmland price inflation and its proposed effects on the farm sector discussed above.

CHAPTER THREE

LITERATURE REVIEW

A majority of the econometric research focusing on farmland values can be separated into two categories, cross sectional and time series analyses. The cross sectional studies have basically tried to explain the variation in agricultural land values among states or within a given state or geographical region. The aim of time series analyses has been the estimation of structural elements or the forecast of future land price levels. Time series research has been primarily undertaken employing aggregate data for the U.S..

Chapter Three reviews some of the more important analyses, briefly noting only limitations relevant to this study. The important variables included in each model are mentioned. The validity of the estimation technique in analyzing farmland prices and the structure of each model are noted.

Cross Section

Murray and Reinsel (1965) investigated the determinants of the variation in farmland values in six Maryland counties. They found agricultural land prices to be a function of population density, rate of growth of population density, per capita income, size of the tract of land, presence of buildings and nearness to the shopping areas. Urban influence on farmland values is a finding of other cross sectional studies.

Hammill (1969) found variation in land prices among Minnesota counties to be largely explained by the percentage of cropland, a measure of crop productivity and distance from urban centers. Two later studies, by Morris and Lindsay (1977) for Northeast U.S. counties and Morris (1978) for the forty-eight contiguous states and ten production regions, found a significant effect of urbanization on farmland values, after differences in agricultural value were accounted for.

A number of cross section studies have examined the incidence of farm programs on farmland values. Gilliam and Hubbard (1971) used regression analysis to study the capitalization of cotton programs into land values in South Carolina. They concluded that cotton program benefits have been capitalized into farmland values. However, Gilliam and Hubbard noted the difficulty in using single equation models to estimate the various factors influencing land values, as

well as the problem of multicollinearity. Reinsel and Krentz (1972), and later Reinsel (1973), also studied the effects of farm programs on average farmland values.

Pasour (1973) investigated the capitalization of property tax rates into farm real estate values in North Carolina. He regressed average county farmland values on the tax rate and other variables related to urban influence, land productivity, farm size and recreational demand. Pasour found property tax reductions are largely capitalized into higher agricultural land values. Repeating the study in 1975 for a cross section of 48 states, he found property taxes, agricultural productivity, farm size and urban influence to be significant in explaining average farmland values.

The cross-sectional analyses discussed above are designed to estimate the influence of factors affecting the variation in farmland values between units at some point in time. The models, however, are not designed to forecast future land values or provide an insight into the factors influencing average farmland values over time. This is the role of time series models.

Time Series

Early Models

The parallel movements of average farmland values and farm income levels prior to the late 1940's prompted

researchers at that time to claim farm income as the sole determinant of average farmland value behavior. Rises in farmland prices coinciding with decreasing or constant levels of current returns in farming into the 1950's resulted in investigations into other factors affecting farmland values.

Studies by Larsen (1948) on the "warranted" value of farmland, that value consistent with levels of current returns, and by Renshaw (1957) finding gross farm income, interest rates and a time trend important in explaining variations in farmland prices, lent support to the theory of non-income factors influencing average farmland values. Articles by Mcwell (1947), Scofield (1957) and Chryst (1965) raised questions concerning non-income factors influencing land values and offered insights into the divergence between movements in farm income and agricultural land values.

Further time series studies investigated the significance of various factors in explaining farmland values, recognizing farm income alone as no longer supplying a reasonable explanation. Three of these are simultaneous equation models presented by Herdt and Cochrane (1966), Tweeten and Martin (1966) and Reynolds and Timmons (1969). All three assume a national market for agricultural land.

Herdt and Cochrane specified a three equation system with supply and demand relations as well as a market clearing identity. Estimating their model for the period

1913 to 1962, they concluded that technological progress, in conjunction with farm price supports, were the primary forces behind rising land prices, with the ratio of prices received to prices paid and the general price level being of lesser importance.

In stating their conclusions, Herdt and Cochrane ignored the effect of the urban demand for land variable included in an earlier specification of their model. Due to a strong simple correlation, (.98), between their proxy for technological change and the urban land variable, the latter was deleted from the final model. Although Herdt and Cochrane in their conclusions granted the effect of urban demand for land is being jointly estimated with the technological advance variable, they failed to note it is indeterminate which of the forces dominates and that the effects of each from the final estimated parameter are inseparable. Herdt and Cochrane, nevertheless, titled their paper, "Land Prices and Technological Advance".

Tweeten and Martin employed a five equation economic model of the U.S. agricultural land market to predict farm real estate price variation. They estimated the model using ordinary, recursive and autoregressive least squares for the period 1923 to 1963. Capitalized benefits from farm programs and pressures for farm enlargement were found to be the most important determinants in land price variation.

The final simultaneous equation model is that of Reynolds and Timmons. Reynolds and Timmons specified a two equation recursive model to determine the principal forces behind agricultural land prices. Land price and land transfer equations were estimated using annual data covering the period 1933 to 1965. Reynolds and Timmons found capital gains, government payments for land diversion, farm enlargement, conservation payments, transfers of farmland and the rate of return on common stock to explain much of the variation in land prices.

Both Reynolds and Timmons (1969) and Tweeten and Martin (1966) used data series as proxies for farm enlargement activity which had undergone significant definitional change over their estimation periods. This change concerned the definition of a farm for statistical purposes. Reynolds (1966) found that approximately one third of the increase in the average size of a farm between 1959 and 1964 was due to this change.

Recent Studies

The rapid land price increases of the 1970's motivated further research on farmland values. These studies include two single equation models of farmland prices, a study evaluating earlier analyses of farmland prices, and a time series study focusing on the credit and debt accumulation aspects of buying farmland.

Klinefelter (1973) and Kuhlman (1979) developed single equation models of U.S. farmland prices. Klinefelter's model was estimated using Illinois state data and Kuhlman's employing aggregate national data.

Klinefelter estimated his single equation model of Illinois land prices for the period 1951 to 1970, assuming the number of land transfers to be exogenous. The author found expected capital gains and farm enlargement exerting the most significant effects on land price variation. Net returns was also significant in explaining rising land prices. Klinefelter was forced to drop variables from earlier specifications of his model due to multicollinearity. Some of the remaining factors hypothesized to affect land values may thus exhibit effects of the deleted variables.

Kuhlman, also assuming a fixed quantity of land available for transfer during each time period, used a distributed lag structure to analyze factors affecting farmland values over the period 1940 to 1977. Net farm income and expected real capital gains were hypothesized to have multi-period effects and were estimated using the Almon polynomial distributed lag procedure. The remainder of the variables were estimated using ordinary least squares.

Kuhlman's results suggested net income from farming to be the most important factor affecting farmland values. Other variables showing significant effects were capital

gains, mortgage interest rates, urbanization of farmland, government payments and demand for food and fiber. Kuhlman also chose to delete insignificant, highly correlated variables from earlier specifications to alleviate multicollinearity problems. The author allows that although the model predicts well, the structural parameters may not be valid.

Another recent time series study is that of Pope et. al. (1979). They evaluated four models of U.S. farmland prices including the simultaneous equation models of Herdt and Cochrane (1966), Tweeten and Martin (1966) and Reynolds and Timmons (1969); and the single equation model of Klinefelter. All four models were described above. The authors re-estimated each model adding more recent data to 1972. The models were also estimated using only data from the postwar years, 1946 to 1972. Klinefelter's model was modified by employing national data.

The models of Tweeten and Martin (1966) and Reynolds and Timmons (1969) exhibited numerous sign changes and insignificant variables for each of the estimation periods. A number of the hypothesized structural relationships between farmland prices and factors influencing them no longer held outside of their original estimation periods. Herdt and Cochrane's three equation model encountered fewer problems. For this reason, and because it lacked lagged dependent variables, it was utilized along with

Klinefelter's model, chosen for its high R-squared, to forecast land prices.

The three period forecasts from the econometric models were compared with univariate Box-Jenkins forecasts to evaluate the models' predictive power. The simultaneous equation model of Herdt and Cochrane provided forecasts of comparable accuracy to the Box-Jenkins models of farmland values over the postwar years, a time of rapidly rising farmland prices. For the longer estimation period, 1913 to 1972, the univariate model outperformed the simultaneous equation model, both within and outside of the sample. The single equation model of Klinefelter performed better than both the Box-Jenkins and Herdt and Cochrane models over the two sample periods.

Pope et. al., concluded the poorest predictions of agricultural land prices appeared to be generated by the simultaneous equation models, although they failed to provide forecasts from the re-estimated Tweeten and Martin and Reynolds and Timmons models, despite their structural difficulties. The authors also failed to pick a unique Box-Jenkins model, choosing three different models and forecasting with each. Their study outlined the need for improved structural and predictive efforts in the area of farmland prices.

A final time series model of importance is that of Shalit and Schmitz (1982). Their analysis was at the individual farm level, with each farmer maximizing utility over time. They viewed land purchases as long-term decisions and examined the credit and debt accumulation aspects of buying farmland. The estimated results of their price equation found accumulated debt to be the principal determinant of farmland prices, with net farm returns being less important. Shalit and Schmitz provided an alternative approach to the analysis of farmland price determination in developing what they termed, a "Life Cycle Model of Land Accumulation".

Other Studies

Many studies other than econometric investigations have been undertaken. Some recent articles have introduced differing hypotheses concerning forces behind, and the implications of, rapidly rising farmland prices.

Melichar (1979) examined the relationship between capital gains and current returns to farming. He concluded that the farming sector is doomed to a low rate of current returns in the foreseeable future. Melichar noted real capital gains on physical assets averaged nearly the size of current returns in farming from 1954 to 1967 and in the 1970's. He suggested farm policy be modified to account for movements in the current rate of returns due to asset appreciation and the influence of real capital gains.

Reinsel and Reinsel (1979) saw population growth, overseas agricultural marketings and inflation as primary forces behind land price appreciation. They outlined possible implications of rising land values and suggested policy changes, including the modification of capital gains taxation and farm real estate value taxes.

Plaxico (1979) sketched plausible alternative scenarios that may result from farmland price inflation. He considered their implications and put forward possible policy alternatives for each scenario. Plaxico noted the paradox of farm leaders seeking programs to solve current problems which result in longer term structural changes, often of an adverse nature. Plaxico, as did Melichar and Reinsel and Reinsel, acknowledged the strong influence of rapidly rising farmland prices on the structure of U.S. agriculture and its effects on the distribution of wealth and income.

Finally, Lins and Duncan (1980), Klinefelter, Penson and Fraser (1980), and White and Musser (1980) analyzed general price inflation's effect on the structure of American agriculture, farmland values and agricultural finance. Each study noted inflation's unequal effect on relative prices as having the most damaging implications for U.S. farming. Improved forecasts of future prices and their variability was seen as important for lenders and agricultural finance in general.

Conclusions-

The literature suggests that new farmland price research is necessary. The study by Pope et. al. (1979) shows the inadequacy of earlier simultaneous equation models in analyzing factors behind current farmland price inflation and forecasting farmland prices. The single equation models of Klinefelter (1973) and Kuhlman (1979) make restrictive assumptions and encounter difficulties in estimating the separate effects of each variable. The studies of Melichar (1979), Reinsel and Reinsel (1979) and Plaxico (1979) suggest the influence of real capital gains and agricultural exports on current farmland price movements. Lins and Duncan (1980), Klinefelter, Penson and Fraser (1980), and White and Musser (1980) outlined the importance of improved forecasts of farmland prices for investors in farmland and those in agricultural finance.

A three equation farmland price model is developed in this study. Farmland prices, net farm income and agricultural exports are chosen as the endogenous variables of the system. The exogenous variables of the farmland price equation are alternative investment returns, relative government payments, real capital gains and the parity price ratio. An autoregressive-moving average (ARIMA) model is also developed for forecasting purposes. These models are discussed in Chapter Four.

CHAPTER FOUR

MODELS AND METHODOLOGY

The Three Equation Model

A simultaneous equation model was developed to analyze farmland price determinants and provide forecasts of average farmland values. The model includes farmland price, net farm income and agricultural exports equations. Each equation, its elements and a priori signs for each variable parameter will be discussed. A description of the data, data sources and summary statistics may be found in Appendix 1.

The theoretical equations of the model are expressed in multiplicative form. The choice of the multiplicative form was made on the basis of: 1) the use of the log-linear form in an earlier model [Shalit and Schmitz (1982)]; and 2) the inability of a linear model to capture any non-linearities in variables of the system and the ability of a non-linear model to account for both linearities as well as non-linearities in the variables. The equations were estimated in natural logs [18].

The Farmland Price Equation-

$$(1) \quad FP(t) = A1 * NFI(t) \quad \overset{A2}{*RCG(t)} \quad \overset{A3}{*SPSI(t)} \quad \overset{A4}{*GPCR(t)} \quad \overset{A5}{*EXT(t)} \quad \overset{A6}{*PAR(t)}$$

Farmland prices (FP) are hypothesized to be a function of net farm income (NFI), real capital gains (RCG), alternative investment returns (SPSI), the relative importance of government payments to agriculture (GPCR), agricultural exports (EXT) and the USDA parity price ratio (PAR).

Net Farm Income (NFI). Net farm income, or current returns to farming, is often theorized as a primary factor in the formulation of farmland values. Farmland is viewed as a production asset in farming. The value of the returns accrued to a production asset is important in the valuation of that asset. Here we will approximate the returns to farmland with net farm income.

Viewing it in terms of an asset valuation model, assuming current returns constant over time:

$$(2) \quad PV(t) = \frac{R(t)}{(1+d)^0} + \frac{R(t+1)}{(1+d)^1} + \dots + \frac{R(t+n)}{(1+d)^n}$$

where, $PV(t)$ is the present value of a tract of land at time t , $R(t)$ represents the current returns to farming in time t , d is the discount rate, a function of the time preference for money and risk (the discount rate is assumed constant

here over time) and n is the time horizon.

So, under these assumptions, changes in d or R will theoretically affect the valuation of the asset farmland. An increase, or expected increase, in net farm returns should result in an accompanying increase in farmland prices, all else constant. Figure 4-1 shows the USDA index of farmland values and U.S. net farm income for the period 1935 to 1980.

Real Capital Gains (RCG). Real capital gains can be defined as changes in the value or price of an asset above general price level changes [19]. The implications of large RCG's for the structure of American agriculture were stated above. Large RCG's have resulted from the recent land price inflation. Figure 4-2 depicts total RCG's from farm real estate since 1940 charted with net farm income over the same period. As can be seen, RCG's from farming have been substantial, particularly in recent years.

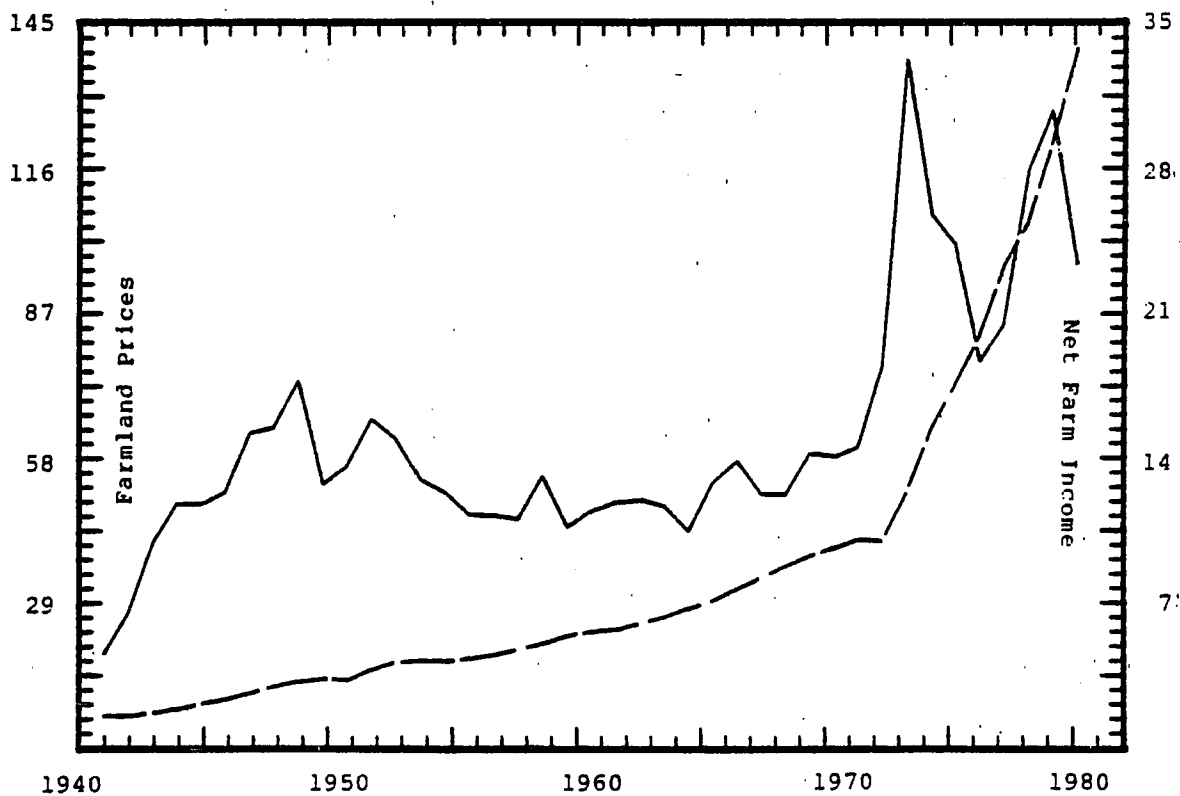
RCG's from farmland, realized and unrealized, could have an effect as large as net income from farming in determining agricultural land prices. Farmland owners may place a value on capital gains from agricultural land appreciation similar to that placed on farm returns. Unrealized capital gains are in effect forced savings and realized gains may be treated as increases in income [Bhatia (1971, 1972)]. Where cash flow problems are absent, this may be the case. The growth in the purchase of agricultural

FIGURE 4-1

The Nominal USDA Index of the Average Value
per Acre of U.S. Agricultural Land and
Total U.S. Net Income from Farming,, 1941 to 1980

Farmland Prices — — — — —
 (1977 = 100)

Net Farm Income —————
 (Billions of Dollars)



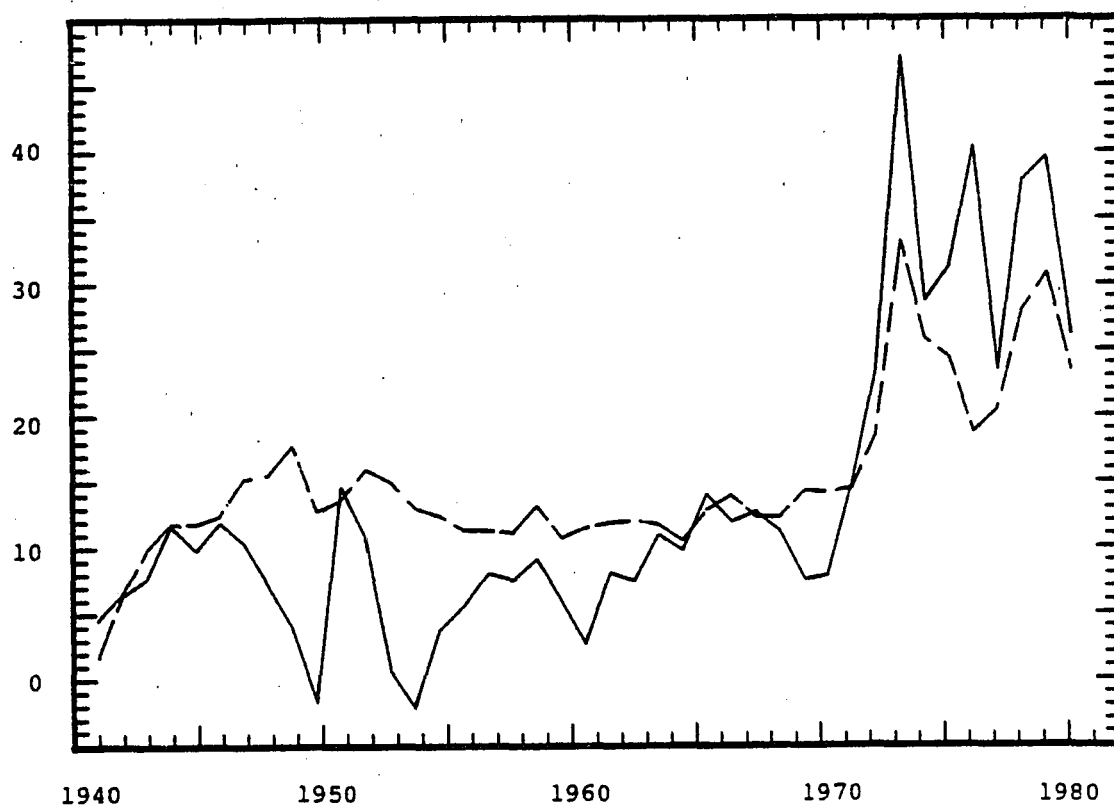
Source: Farm Real Estate Market Developments, various years
 and Agricultural Statistics, various years.

FIGURE 4-2

Total Real Capital Gains from Farm Real Estate
and U.S. Net Farm Income, 1940 to 1980

Real Capital Gains _____
Net Farm Income - - - - -

(Billions of Dollars)



Real capital gains are the value of total capital gains from farm real estate deflated by the GNP price deflator.
Source: Agricultural Statistics, various years.

land by farmers and non-farmers for speculative purposes adds support to this. An increase in expected RCG's would cause farmland prices to be bid up.

Expectations of future RCG's are important in the determination of farmland prices. As with general price inflation, these expectations are strongly influenced by the past history of farmland value increases. Previous research [Kuhlman (1979)], has indicated RCG's have a multi-period lagged effect on farmland prices. A declining geometric weighted average of real capital gains from farmland of six lagged periods was used in the land price equation [20]. Real capital gains, as used in this study, are measured as the percentage change in average farmland values above general price inflation, measured by the GNP price deflator.

Alternative Investment Returns (SPSI). As discussed above, investors see farmland as a store of value and a means to diversify their portfolios. Portfolio analyses [Robichek, et. al. (1978) and Feldstein (1980)] have found farmland to be a viable alternative investment based on its relative risk, returns and price gains, which have outpaced gains in the stock market in recent years.

One measure of returns to stocks is the Standard and Poors stock price index. This index is a weighted average of selected, diversified stocks of corporations in the areas of manufacturing, finance, utilities and transportation. An overall increase in the value of the group of stocks will

result in an increase in the index.

A negative sign is expected for this variable in the land price equation. A relative increase in the returns to stocks would direct investment funds away from the farmland market, liquidity and risk factors aside. This would result in the easing of demand pressure on farmland. A decrease in the Standard and Poors index would find farmland a more attractive investment, relative to stocks, all else constant. The rate of alternative returns, the Standard and Poors index, net of inflation, will be used.

Relative Importance of Government Payments (GPCR). Payments by the government to farmers have long been seen as a means to stabilize farm income, control supply of farm products and support farm output prices. Many argue these payments, particularly those linked to land, are capitalized into land values [Herdt and Corchrane (1966), Reinsel (1973) and Kuhlman (1977)]. For example, a government support program tied to soybean production would result in an increase in the value of farmland currently utilized in production of soybeans, particularly if the programs are seen to be of a longer range. As mentioned above, Reinsel and Krentz (1972) and Reinsel (1973) found farm programs to be a dominant factor in explaining farmland prices in cross-sectional studies. Reinsel and Krentz estimated that in 1970 the capitalization of government farm programs represented eight percent of the value of farmland

nationally. The relative importance of government payments, measured as total government payments to farmers over total receipts from farming, is expected to carry a positive sign in the Land Price Equation.

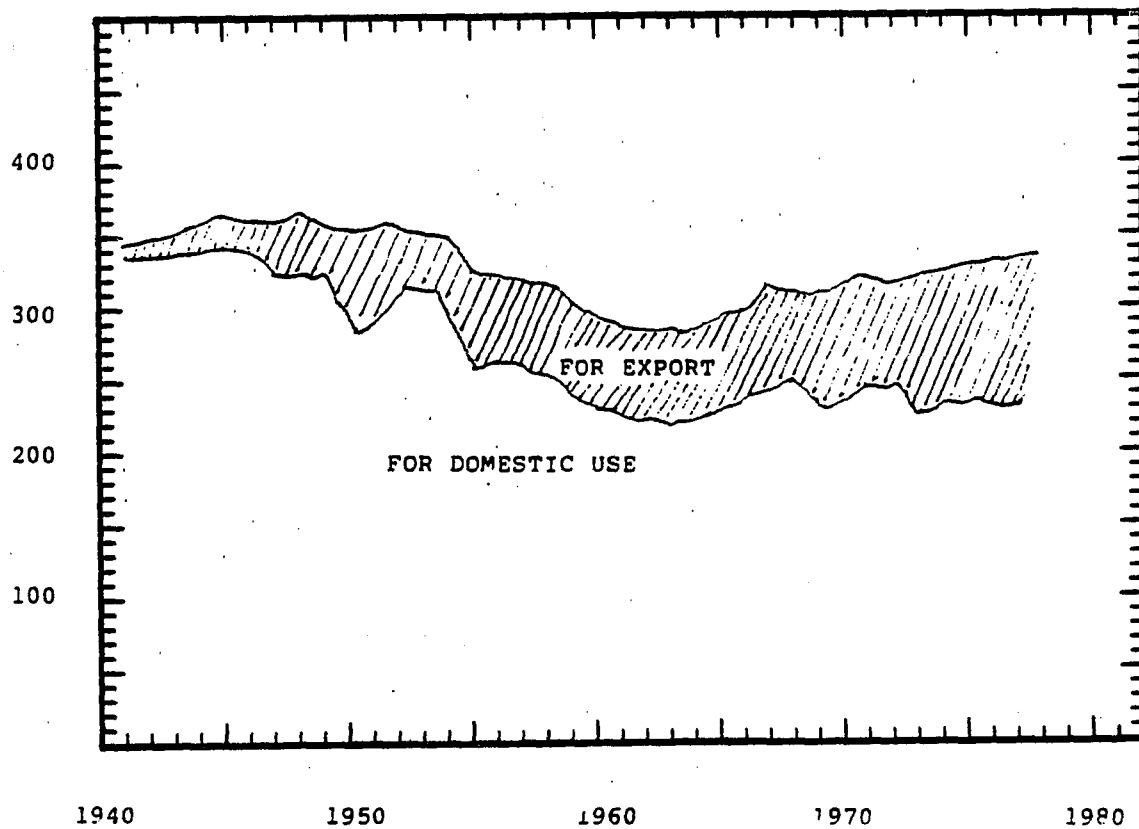
U.S. Agricultural Exports (EXT). Since the early 1970's, production for export has accounted for an increasing share of total agricultural production in the U.S. [21]. A combination of large surpluses in agricultural production and stable domestic demand for farm products has led American farmers to look to foreign sales to expand their markets. In addition, there presently exists a reliance upon agricultural exports to offset deficits in trade resulting from the dependence of the U.S. upon higher priced foreign energy supplies. U.S. farm exports could become more important in the future. Agricultural exports may be an effective foreign policy given the world food situation.

Increased export demands have been a driving force behind recent expansion in U.S. agricultural production. Figure 4-3 shows the total acreage of crops harvested in the U.S. from 1940 to 1977 and the acreages harvested for export and domestic use. In 1980, the export percentage of the value of total U.S. agricultural sales reached 28.9 percent. This figure was 39 and 35 percent in 1979, for the Delta States and Corn Belt production regions, respectively [22].

FIGURE 4-3

Acreage of Crops Harvested in U.S.
For Domestic Use and Export, 1940 to 1977

Millions of Acres



Source: Agricultural Land Availability, July, 1981.

The rise in agricultural exports, bringing an increase in the demand for agricultural products, increased production and an accompanying increase in the demand for farmland, would result in a rise in agricultural land prices. This may be the case for U.S. agricultural exports. The growth in foreign marketing of U.S. agricultural products may put upward pressure on farmland prices.

A positive sign is expected for the coefficient on this variable in the Farmland Price Equation.

Parity Price Ratio (PAR). The USDA parity price ratio provides a per unit measure of the buying power of farm commodities in terms of the goods and services currently purchased by farmers. This ratio index is in relation to the buying power of those commodities in some base year [23]. The parity ratio is incorrectly used as a barometer of: 1) total farm sector well-being, 2) farm income and 3) farmers total purchasing power. The parity ratio is not an indicator of any of the above. It is a measure of price relationships. Price relationships alone do not determine farmers' welfare. Production technology, quantities of farm products sold, supplementary income, and how these factors interact with price relationships are also important.

The parity price ratio does measure the overall net margin per unit of production. The margin is the difference between what a farmer receives for unit of output and the

costs of producing that unit of output. Figure 4-4 shows the variability in the parity price ratio since 1945. The parity price ratio, with the exception of 1973 and 1974, has trended downward over this period. When net margin per unit of production decreases, rising farm costs per unit are outpacing growth in the price of farm products. A cost-price squeeze for farmers results.

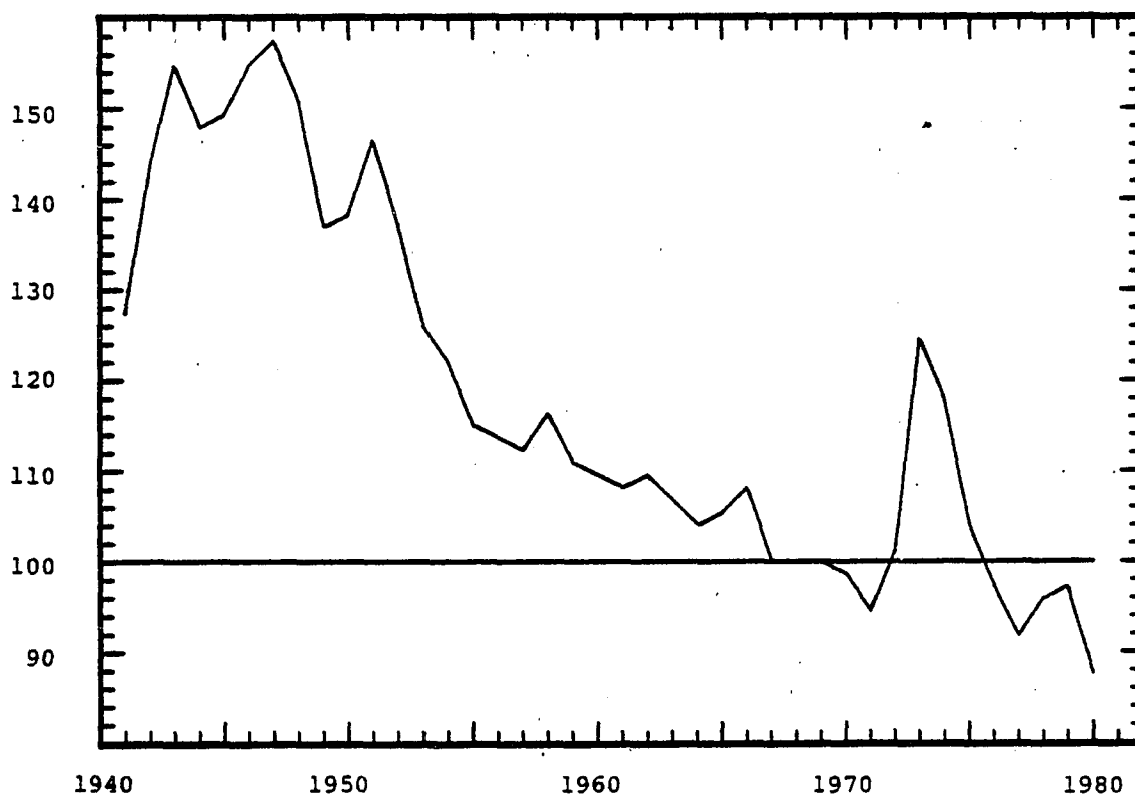
This cost-price squeeze pressures farmers into: 1) seeking other income sources, 2) increasing production, and/or 3) altering their production marketing system. Technological advances during the 1950's allowed farmers to increase production per unit of land and offset some of the pressure of a declining net margin per unit of production. However, since the 1960's technological advance has slowed, not allowing farmers to increase production per acre in response to the cost-price squeeze [24]. When production has been maximized on existing land in this situation, a decision is made to: 1) seek off-farm income, 2) expand the land base or 3) go out of business. All three have occurred. The latter two provide the link between the parity price ratio and farmland price movements.

Aggressive farmers responded to the cost-price squeeze by expanding their output through the buying out of their neighbors. The average size of a farm has increased from 175 acres in 1940 to 450 acres in 1979. An average of 2,000 farms per week have gone out of business since 1950 [25].

FIGURE 4-4

USDA Parity Price Ratio

(1967 = 100)



Source: Agricultural Statistics, various years.

Figure 4-5 shows the increase in the average size of farms and the decrease in the total number of farms since 1945. Notice the parity price ratio closely follows the decline in the total number of farms in the U.S.. The ratio has been seen to track structural changes in farming. Some argue that the cost-price squeeze is a major reason for the increase in farm size and the decrease in the number of farms in the U.S. [U.S. GAO (1980)].

The increased purchasing of farms and farmland to expand production in response to the cost-price squeeze has resulted in the bidding up of the price of farmland. Expanded acreage and production has allowed farmers to maintain higher levels of farm income. A substitution of land for other inputs due to rising costs and relative additions to profit and capital gains may also have occurred. There has been a demand for farm acreage to expand. A declining net margin per unit of production has put upward pressure on farmland prices. The parity price ratio is hypothesized to have a negative sign in the farmland price equation [26].

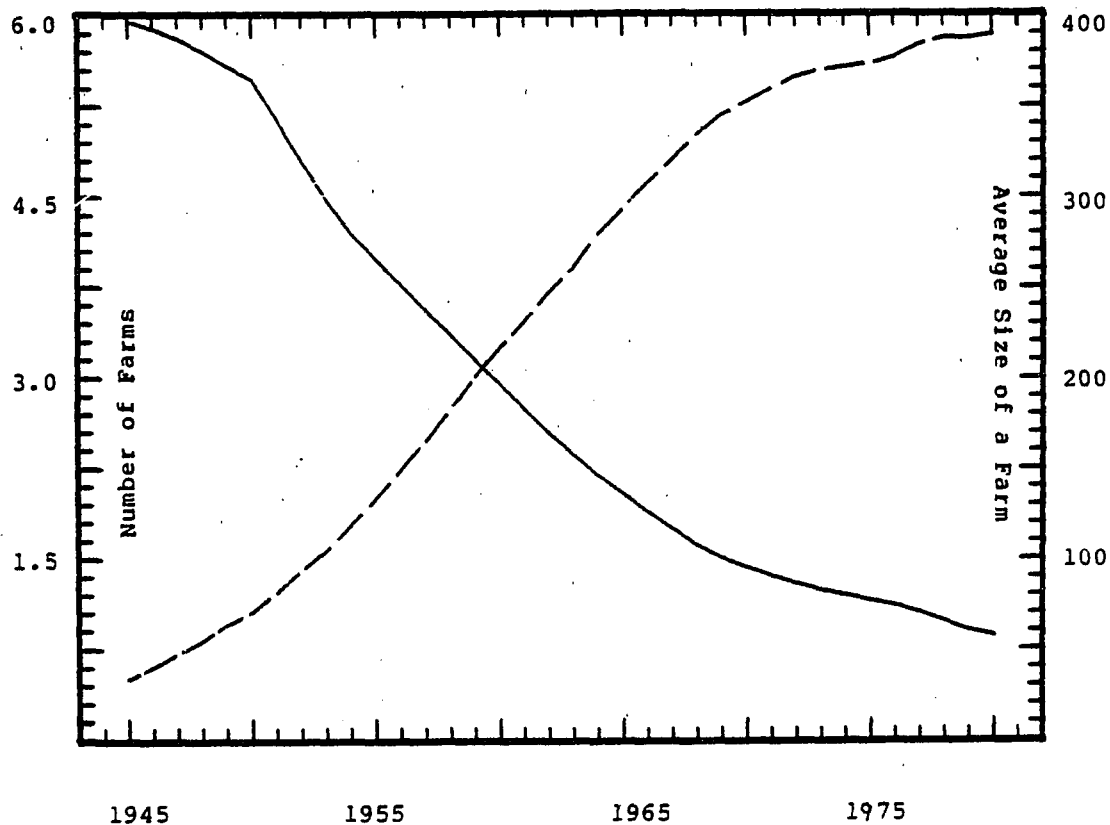
The Net Farm Income Equation

$$(3) \quad \text{NFI}(t) = B1 * \overset{B2}{\text{PAR}}(t) * \overset{B3}{\text{PROD}}(t) * \overset{B4}{\text{GVTP}}(t) * \overset{B5}{\text{EXT}}(t)$$

FIGURE 4-5

Average Size of a Farm and
Total Number of Farms, 1945 to 1980

Average Size of Farms (acres) — — — — —
Total Number of Farms (millions) — — — — —



Source: Agricultural Statistics, various years.

Net farm income (NFI) is hypothesized to be a function of the parity price ratio (PAR), the USDA production index (PROD), total government payments (GVTP), and U.S. agricultural exports, (EXT).

Parity Price Ratio (PAR). The USDA parity price ratio, introduced above in the Land Price Equation, is hypothesized to influence U.S. net farm income. As the level of per unit prices received rises in relation to per unit prices paid, farmers' situations improve, quantities and other factors remaining the same. As discussed above, the parity price ratio is a measure of price relationships, not an indicator of farmers' welfare or farm income.

Rising energy costs, land related costs and other production input outlay costs, outpacing increases in prices for farm products, have resulted in a decreasing parity price ratio over much of the sample period, 1941 to 1980. This is mirrored in the cost-price squeeze discussed above concerning the parity ratio and farmland prices in the Farmland Price Equation. The USDA parity price ratio is expected to have a positive estimated coefficient in the Net Farm Income Equation.

USDA Production Index (PROD). The production index published by the USDA is a weighted average of indices of output for various crops and livestock. This index is a relative measure of total production of the farming sector.

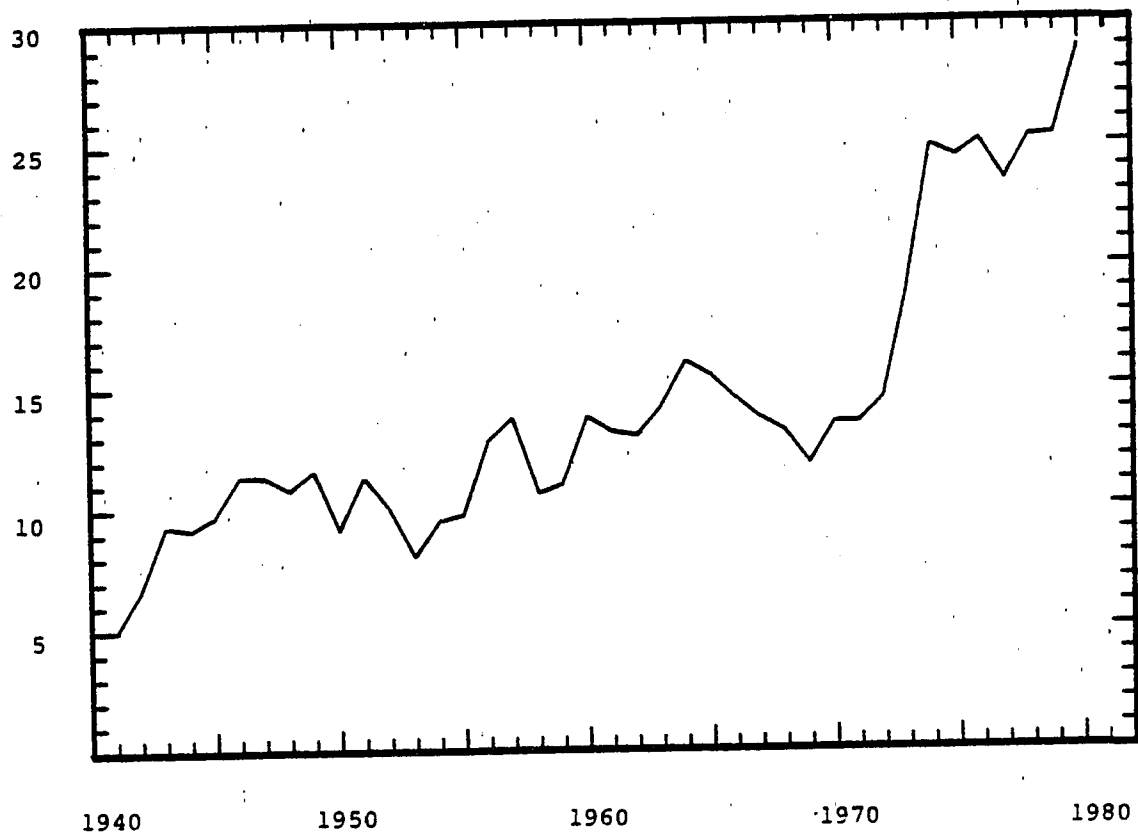
An increase in output should result in an increase in net farm income. This hypothesis may not seem straightforward, given the relationship of costs, revenues and output. It does not necessarily hold that an increase in output will result in the rate of return to production assets, net revenues over outlays, increasing. A rise in the total figure, net income, however, should occur, assuming marginal profit, that addition to profit from an incremental increase in output, remains positive, given costs and prices. A positive sign is expected for the production index in the Net Farm Income Equation.

Government Payments (GVPT). Direct government payments to farmers, as discussed above, have been utilized as a farm policy tool to stabilize income and control prices. Government payments to farmers are an addition to total revenues from farming and thus favorable to the short term farm income situation. An increase in payments to farmers should result in a rise in net farm income. Total direct government payments to farmers will be used here rather than the variable GPCR, government payments over total cash receipts, used in the Farmland Price Equation.

U.S. Agricultural Exports (EXT). Sales of farm products abroad have accounted for an increasing share of total U.S. agricultural revenues, as seen in figure 4-6. An increase in foreign purchases of U.S. agricultural products provides an expanded market for American farmers.

FIGURE 4-6

The Percentage of The Value Of U.S. Cash Receipts
From Farming Comprised By the Value of U.S.
Agricultural Exports, 1941 to 1980



Source: Agricultural Statistics, various years.

This expanded market has supported higher levels of net farm income, supplementing periods of sluggish domestic demand and lower farm product prices. It also contributes to record and near record levels of net farm income in more favorable years, such as 1973 and 1974.

Agricultural exports will be expected to have a direct influence on net farm income. As in the Land Price Equation, total value of U.S. farm exports will be used.

Agricultural Exports Equation-

Due to the institutional arrangements affecting agricultural exports and exports in general, a truly accurate Agricultural Exports Equation is difficult to specify. Barriers to trade such as quotas, tariffs and embargoes are for the most part outside of the realm of domestic and foreign market forces. They are of a political nature or linked to some protectionist policy due to a comparative advantage or price difference. Examples are the five year USSR wheat deal of 1976, followed by the USSR grain embargo of 1979, and the community agricultural policies of the European Common Market countries. These would be difficult to measure, forecast, or react to beforehand. The network of foreign supply and demand possibilities further complicates the task.

A simple, representative model of what may be termed a "supply-side" nature, will be estimated.

$$(4) \quad \text{EXT}(t) = C1 * \text{PROD}(t) + C2 * \text{SUB}(t) + C3 * \text{DUM} + C4 * \text{DUM} * e$$

U.S. farm exports (EXT) is hypothesized to be a function of the USDA index of agricultural output (PROD), exports subsidized by the U.S. government (SUB) and a dummy variable (DUM).

USDA Production Index (PROD). An increase in U.S. farm sector output, as measured by the USDA production index, should result in an increase in the value of U.S. farm exports. A year of high crop and livestock output would more likely produce an available surplus for foreign markets than a poor year. Inventoried surpluses could partially offset this. Overall, however, a relative increase in farm output is expected to result in an increase in the value of agricultural exports.

Subsidized Exports (SUB). Subsidized exports are those agricultural products purchased by the U.S. government for distribution under designed programs of foreign aid or sale. Included in this subsidized category are exports under P.L. 480 or the Food for Peace program, formally called the Agricultural Trade Development and Assistance Act of 1954, those under the Lend-Lease programs following World War II, those connected to the Foreign Assistance Act of 1961, and exports from other government programs. A positive sign on government farm purchases for subsidized export is expected in this equation.

Dummy Variable (DUM). The sudden surge upward in OPEC and foreign oil prices in the mid-1970's created a demand for agricultural exports to offset trade deficits associated with the rising value of imported energy. The total value of U.S. agricultural exports grew at an annual compounded rate of over 15 percent for the period 1973 to 1980 compared to a rate of 3.5 percent for the previous eight years. The real annual rates for 1973 to 1980 and 1965 to 1972 were 6.8 and -0.06 percent, respectively [27]. As long as the U.S. remains energy dependent, the prospect of a demand for farm exports to balance international trade deficits exists.

The dummy variable equals one for 1974 to 1980. It is zero for all other years. A positive coefficient on the dummy variable is expected. Due to the multiplicative specification of the Agricultural Exports Equation, a positive coefficient does not translate into an upward shift in the regression line, but into an increase in the slope of the line.

Methodology for the Three Equation Model

The model as described above is the three equation system:

$$\begin{aligned}
 (1) \quad FP(t) = & A1 * NFI(t) \quad \overset{A2}{*RCG(t)} \quad \overset{A3}{*SPSI(t)} \quad \overset{A4}{*GPCR(t)} \quad \overset{A5}{*EXT(t)} \\
 & \quad \quad \quad \overset{A6}{*PAR(t)} \quad \overset{A7}{*EXT(t)}
 \end{aligned}$$

$$(3) \quad NFI(t) = B1 * PAR(t) \quad \overset{B2}{*PROD(t)} \quad \overset{B3}{*GVTP(t)} \quad \overset{B4}{*EXT(t)} \quad \overset{B5}{*EXT(t)}$$

$$(4) \quad \text{EXT}(t) = C1 \cdot \text{PROD}(t)^{C2} \cdot \text{SUB}(t)^{C3} \cdot e^{C4 \cdot \text{DUM}}$$

Since the data was transformed into natural logs, the model to be estimated is:

$$(5) \quad \ln \text{FP}(t) = \ln A1 + A2 \cdot \ln \text{NFI}(t) + A3 \cdot \ln \text{RCG}(t) + A4 \cdot \ln \text{SPSI}(t) + A5 \cdot \ln \text{GPCR}(t) + A6 \cdot \ln \text{EXT}(t) + A7 \cdot \ln \text{PAR}(t)$$

$$(6) \quad \ln \text{NFI}(t) = \ln B1 + B2 \cdot \ln \text{PAR}(t) + B3 \cdot \ln \text{PROD}(t) + B4 \cdot \ln \text{GVTP}(t) + B5 \cdot \ln \text{EXT}(t)$$

$$(7) \quad \ln \text{EXT}(t) = \ln C1 + C2 \cdot \ln \text{PROD}(t) + C3 \cdot \ln \text{SUB}(t) + C4 \cdot \text{DUM}$$

Due to expected correlation of the dependent variables with the error terms using equation by equation ordinary least squares, the model was estimated as a system of equations. A two stage least squares-instrumental variables technique was utilized for the estimation of the model. The endogenous variables of the system are farmland prices (FP), net farm income (NFI) and agricultural exports (EXT). The remaining variables are taken as the exogenous variables or, in this case, the instrumental variables of the system [28].

Initial estimation of the system found the error terms of equations (5), (6) and (7) to be first order serially correlated. The estimates are thus inefficient. To remedy the problem an iterative, first order serial correlation

maximum likelihood-instrumental variables technique was employed. Consistent estimates of the three equations were obtained and the first order serial correlation coefficients were estimated for each equation [29].

Univariate Model

A univariate farmland price model was developed to forecast farmland prices. The model was estimated, and forecasts made, using the Box-Jenkins methodology. A brief description of the theory behind the technique and the technique itself follows.

Time Series Processes

There exists an on-going process generating a time series according to certain rules. Identifying the process and using it to forecast future values of the data is an aim of time series analysis.

One generating process is an auto-regressive (AR) process. In a univariate context, an n th order auto-regressive process is:

$$(8) \quad X(t) = a(1)*X(t-1) + a(2)*X(t-2) + \dots + a(n)*X(t-n) + Z(t)$$

where, $Z(t)$ is a white noise, serially uncorrelated process and $a(i)$ are coefficients on the lagged values of $X(t)$ [30]. $X(t)$ depends on a weighted sum of its past values and a random disturbance term.

A second process is a moving average (MA) process. An n th order moving average process is:

$$(9) \quad X(t) = b(1)*Z(t-1) + b(2)*Z(t-2) + \dots + b(n)*Z(t-n) + Z(t)$$

where, $Z(t)$ is a white noise, serially uncorrelated process and $b(i)$ are the coefficients on the lagged values of $Z(t)$. $X(t)$ is completely described by a weighted sum of current and lagged random disturbances.

A mixed auto-regressive moving average (ARMA) process exists. An ARMA process of order p, q , where p denotes the order of the AR process and q of the MA, is:

$$(10) \quad X(t) - a(1)*X(t-1) - a(2)*X(t-2) - \dots - a(p)*X(t-p) = b(1)*Z(t-1) + b(2)*Z(t-2) + \dots + b(q)*Z(t-q) + Z(t)$$

The processes discussed above can also be used to describe time series containing seasonal or cyclical patterns.

Finally, a time series process is said to be covariance stationary, or stationary to the second moment, if the particular mean and variance of the realization of the process, $X(t)$ is independent of a particular period of time. The Box-Jenkins methodology employed in this study requires stationary time series for analysis.

A process is mean and covariance stationary if:

$$(11) \quad E[X(t)] = E[X(t+m)]$$

$$(12) \quad E[(X(t) - \text{MEAN}(X))^2] = E[(X(t+m) - \text{MEAN}(X))^2]$$

$$(13) \quad E[(X(t) - \text{MEAN}(X)) * (X(t+m) - \text{MEAN}(X))] = \\ E[(X(t+k) - \text{MEAN}(X)) * (X(t+m+k) - \text{MEAN}(X))]$$

for all t , k , and m . $E[\]$ is the expectations operator.

Many of the time series encountered in practice may be made stationary by differencing one or more times. A time series process which is made stationary by the application of a time invariant filter such as differencing, is known as an integrated process. An integrated ARMA process that has been differenced D -times is known as an ARIMA process of order P, D, Q [31].

The Model

The univariate model is of the form:

$$(14) \quad FP(t) - a(1)*FP(t-1) - a(2)*FP(t-2) - \dots - \\ a(p)*FP(t-p) = b(1)*Z(t-1) + b(2)*Z(t-2) + \dots + \\ b(q)*Z(t-q) + Z(t)$$

Finding the values for $a(i)$, $b(i)$, P , D , and Q and using the estimated model to forecast values of farmland prices is the aim of this portion of the study. The Box-Jenkins

methodology is described below.

The Box-Jenkins Technique

This method, originally developed by engineers G.E.P. Box and G.M. Jenkins to analyze and forecast time series, consists of four steps; identification, estimation, diagnostic checking and finally, forecasting. The first three will be discussed below, with forecasting discussed in Chapter Six.

Identification. Assuming the time series is or has been made mean and covariance stationary, the autocorrelation function is first estimated to aid in identification of the process generating the series [32]. Analysis of a plot of the autocorrelations, up to a reasonable lag, and knowledge of typical patterns for certain time series processes, leads to identification of candidates for the underlying process.

Estimation and Diagnostic Checking. The processes, ARIMA (P,D,Q), hypothesized from the identification step are estimated using a maximum likelihood technique [33]. Given a particular P,D,Q, the parameters are estimated and the residuals are computed. These residuals are used in the diagnostic checking of the model.

If the model is approximately correct, the error terms of the model are white noise, a random time series process described above. The hypothesis of white noise is tested

using a Box-Pierce statistic from the autocorrelations of the residuals. The Box-Pierce statistic:

$$(15) \quad R = N \sum_{k=1}^K r(k)^2$$

where, N is the total number of observations, $r(k)$ is the autocorrelation for order k , and K is the maximum order chosen for the autocorrelation function. The Box-Pierce statistic is distributed chi-squared with $(K-P-Q)$ degrees of freedom. A further diagnostic check is a comparison of the time series fitted by the estimated model and the actual time series data. Root mean squared errors were calculated [34].

CHAPTER FIVE

ESTIMATED RESULTS

The Three Equation Model

The estimated results, including coefficients, standard errors, t-statistics, adjusted and unadjusted R-squareds, and standard errors of regression are found in Tables 5-1, 5-2 and 5-3, for the Farmland Price, Net Farm Income and Agricultural Export Equations, respectively. All parameters are significant at the the .10 level, except the ccefficient on subsidized exports, lnSUB in the Agricultural Exports Equation. All parameters carry the hypothesized signs, except that on the relative value of government payments variable, lnGFCR in the Farmland Price Equation.

The first order serial correlation coefficients, RH01, RH02 and RHC3, are significant, justifying the use of the first order serial correlation correction technique. The adjusted R-squareds, 0.992, 0.886 and 0.903 for the Farmland Price, Net Farm Income and Agricultural Exports Equations, respectively, are relatively high, suggesting a good fit of the models to the data. The R-squared values were calculated with a procedure recommended by Tomek (1973) for use with instrumental variables or two stage least squares

TABLE 5-1

Estimation Results for the Three Equation
Farmland Price Model

The Farmland Price Equation

Dependent Variable: lnFP

Right hand Variable	Estimated Coefficient	Standard Error	T-Statistic
lnA1**	6.988	0.644	10.83
lnNFI**	0.693	0.118	5.89
lnRCG**	1.213	0.446	2.72
lnSPSI**	-0.110	0.048	-2.28
lnGPCR**	-0.053	0.016	-3.41
lnEXT**	0.257	0.068	3.78
lnPAR**	-2.594	0.212	-12.22

R-squared= 0.994

Adjusted R-squared= 0.992

Sum of the Squared Residuals= 0.15771

Standard Error of the Regression= 0.06913

First Order Serial Correlation Coefficient RHO1:

Estimated Coefficient= 0.426

Standard Error= 0.155

T-Statistic for RHO1= 2.74**

* significant at the .10 level

** significant at the .05 level

TABLE 5-2

Estimation Results for the Three Equation
Farmland Price Model

The Net Farm Income Equation

Dependent Variable: lnNFI

Right hand Variable	Estimated Coefficient	Standard Error	T-Statistic
lnB1**	- 8.870	1.726	-5.13
lnEXT**	0.203	0.056	3.59
lnGVTP*	0.049	0.029	1.70
lnPAR**	2.066	0.320	10.17
lnPROD**	1.602	0.321	4.99

R-squared= 0.898

Adjusted R-squared= 0.886

Sum of the Squared Residuals= 0.45027

Standard Error of the Regression= 0.11342

First Order Serial Correlation Coefficient RHO2:

Estimated Coefficient= 0.743

Standard Error= 0.110

T-Statistic for RHO2= 6.71**

* significant at the .10 level

** significant at the .05 level

TABLE 5-3

Estimation Results for the Three Equation
Farmland Price Model

The Agricultural Exports Equation

Independent Variable: lnEXT

Right hand Variable	Estimated Coefficient	Standard Error	T-Statistic
lnC1**	-6.441	2.191	-2.93
lnPROD**	3.269	0.465	7.03
lnSUB	0.044	0.119	0.36
DUM**	0.640	0.206	3.09

R-squared= 0.910

Adjusted R-squared= 0.903

Sum of the Squared Residuals= 2.92776

Standard Error of the Regression= 0.28517

First Order Serial Correlation Coefficient RH03:

Estimated Coefficient= 0.663

Standard Error= 0.145

T-Statistic for RH03= 4.58**

* significant at the .10 level

** significant at the .05 level

estimation techniques.

The analysis of estimated coefficients of the variables of each equation is below. Since the model was estimated with the equations transformed by natural logs, the estimated coefficients may be interpreted as constant elasticities [35].

The Farmland Price Equation

The coefficient on the variable net farm income, $\ln NFI$, was estimated at 0.693. A one percent increase in net farm income will result in, approximately, a 0.7 percent increase in farmland prices, all else constant. This result mirrors the conclusions of earlier studies that U.S. agricultural land prices are linked to net returns from farming [36]. The significance of the remaining coefficients of this equation supports the premise that factors other than net farm income are important in farmland price determination.

The results for real capital gains are also as expected. The estimated coefficient of 1.213 means a one percent rise in the weighted average of six lagged periods of real capital gains from farmland results in a 1.21 percent increase in farmland prices, all else constant. A direct influence of expected real gains from farmland, as measured by RCG, on farmland prices has been found. Farmland owners, viewing gains from land price appreciation, realized or unrealized, as an income from land holdings above returns from farming, capitalize these expectations

into higher farmland prices.

The estimated negative coefficient for alternative returns, $\ln SFSI$, is as hypothesized. As stock prices rise/fall, measured by the real Standard and Poors Stock Index, farmland prices will fall/rise, all else constant. A nine percent fall in SPSI will bring about a one percent increase in farmland prices, as investors look to farmland as an alternative investment, holding all else the same.

The results for the relative value of government payments to total cash receipts, $\ln GPCR$, are not as expected, the estimated coefficient exhibiting a negative sign. A possible explanation for this result lies in the denominator of the variable GPCR. An increase in total cash receipts from farming, the denominator of GPCR, in a period of relatively stable or declining government payments, the numerator of GPCR, would result in a decrease in GPCR. Relative increases in total cash receipts and thus farm income would be favorable to farmland price increases. In this situation, farmland prices and GPCR would be negatively correlated. The simple correlation between farmland prices and relative government payments was -0.135 over the sample period.

The positive sign on the value of agricultural exports, $\ln EXT$, is in agreement with a priori expectations. A four percent increase in the value of agricultural exports, EXT , will bring, approximately, a one percent increase in

farmland prices, all else the same. As U.S. farm exports increase, farmland prices rise.

The final variable in the farmland price equation, the parity price ratio, $\ln PAR$, is found to have a negative estimated coefficient, as expected. The decline in the parity ratio, mirroring the decline in net margin return per unit of production, positively influences farmland prices. A one percent decrease in the USDA parity price ratio results in a 2.5 percent increase in farmland prices, all else equal.

Net Farm Income Equation

The estimated coefficient for the value of U.S. agricultural exports, $\ln EXT$, is positive, as expected. As the value of U.S. agricultural exports increase, net farm income rises, all else the same. A coefficient of 0.20 was found for $\ln EXT$. A five percent rise in the value of U.S. foreign farm marketings will result in a one percent rise in net farm income, all else equal.

An estimated coefficient of 0.059 was found for the variable, $\ln GVPT$, direct government payments to farmers. The coefficient, as hypothesized, carries a positive sign. The magnitude of the coefficient, however, is surprising. This result translates into, holding all else constant, a 16 percent rise in government payments to farmers increasing net farm income by only one percent.

Both the parity price ratio variable, $\ln PAR$, and the production index variable, $\ln PROD$, have the expected positive coefficients. A one percent increase in either of the variables, holding all else constant, will result in approximately a two percent rise in net farm income. The parity price index and the index of farm output are found to be important in determining net farm returns, as anticipated.

The Agricultural Exports Equation

The index of production, $\ln PRCD$, carries a positive sign, as expected, in the Agricultural Exports Equation. The estimated coefficient of 3.26 translates into a one percent rise in the USDA production index resulting in roughly a three percent increase in EXT , all else equal. Relative increases in aggregate production provide a surplus for foreign markets. In response, the value of agricultural exports increase.

The estimated coefficient on the variable, $\ln SUB$, or subsidized exports, is positive, as hypothesized. The variable, however, is insignificant in explaining movements in farm exports over the sample period. The government purchase of farm output for export under specific programs does not have a significant effect on the total value of U.S. foreign agricultural marketings. This result could be explained by the discontinuity of specific government export and food aid programs.

Finally, the dummy variable, DUM, carries a positive coefficient, 0.64. This result is consistent with the hypothesis of the upward movement in imported energy prices creating a need to increase U.S. agricultural exports to offset trade deficits. The positive coefficient means the relationship between the dependent variable, $\ln EXT$, and the independent variables, $\ln PROD$ and $\ln SUB$, is scaled upward for the subsample, 1974 to 1980. A structural change in the relationship between agricultural exports and the variables of this equation occurs after 1973. The dummy variable becomes a positive scale factor, analogous to increasing the slope of the regression equation line.

Plots of the actual and fitted values of the three equations may be found in figure 5-1.

The Univariate Model

The results of each step of the Box-Jenkins procedure will be presented below, excluding forecasting results, which may be found in Chapter 6.

The Autocorrelation Function

The sample autocorrelation function results of the farmland price time series may be found in table 5-4a. The corresponding correlogram is in figure 5-2a. The total lag length was chosen to be ten, that is $K = 10$. The time series was examined for stationarity.

FIGURE 5-1

Actual and Fitted Values of Dependent
Variables of the Three Equation Model

Actual Values ○
Fitted Values ▲

Farmland Prices

1967 = 100

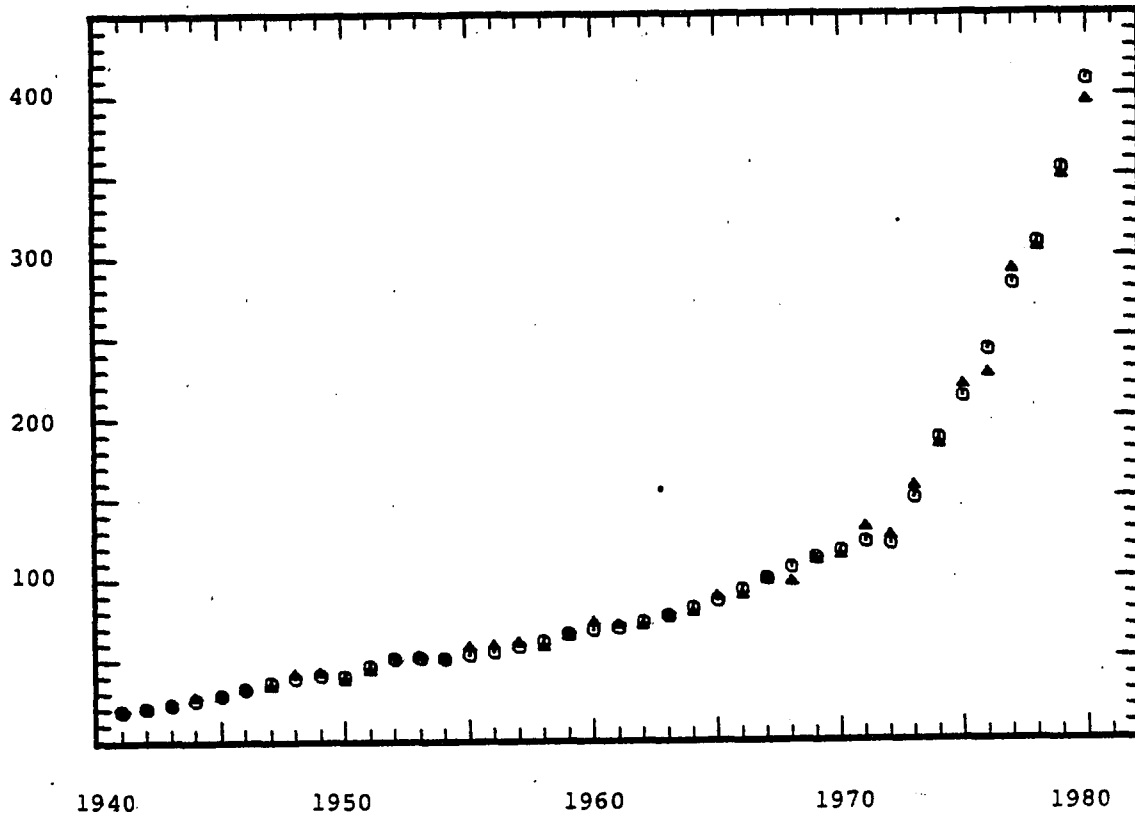


FIGURE 5-1 (continued)

Actual and Fitted Values of Dependent
Variables of the Three Equation Model

Actual Values ○
Fitted Values ▲

Net Farm Income
Billions of Dollars

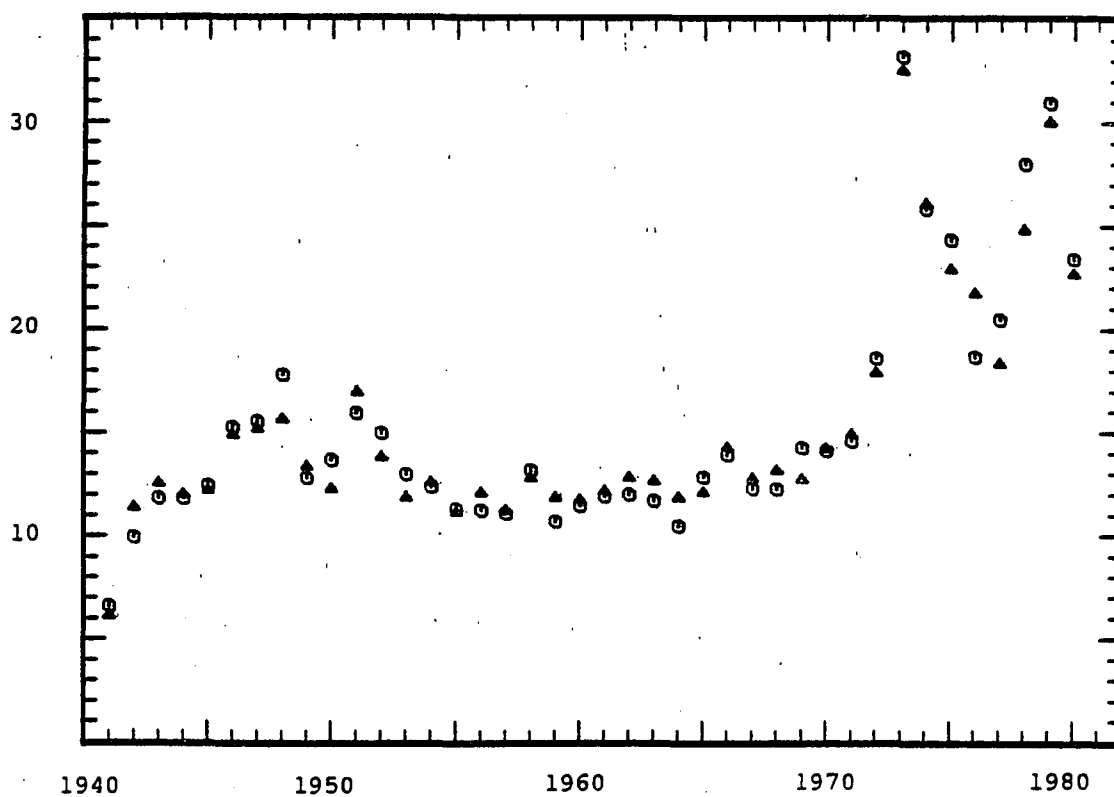


FIGURE 5-1 (continued)

Actual and Fitted Values of Dependent
Variables of the Three Equation Model

Actual Values ○
Fitted Values ▲

U.S. Agricultural Exports

Billions of Dollars

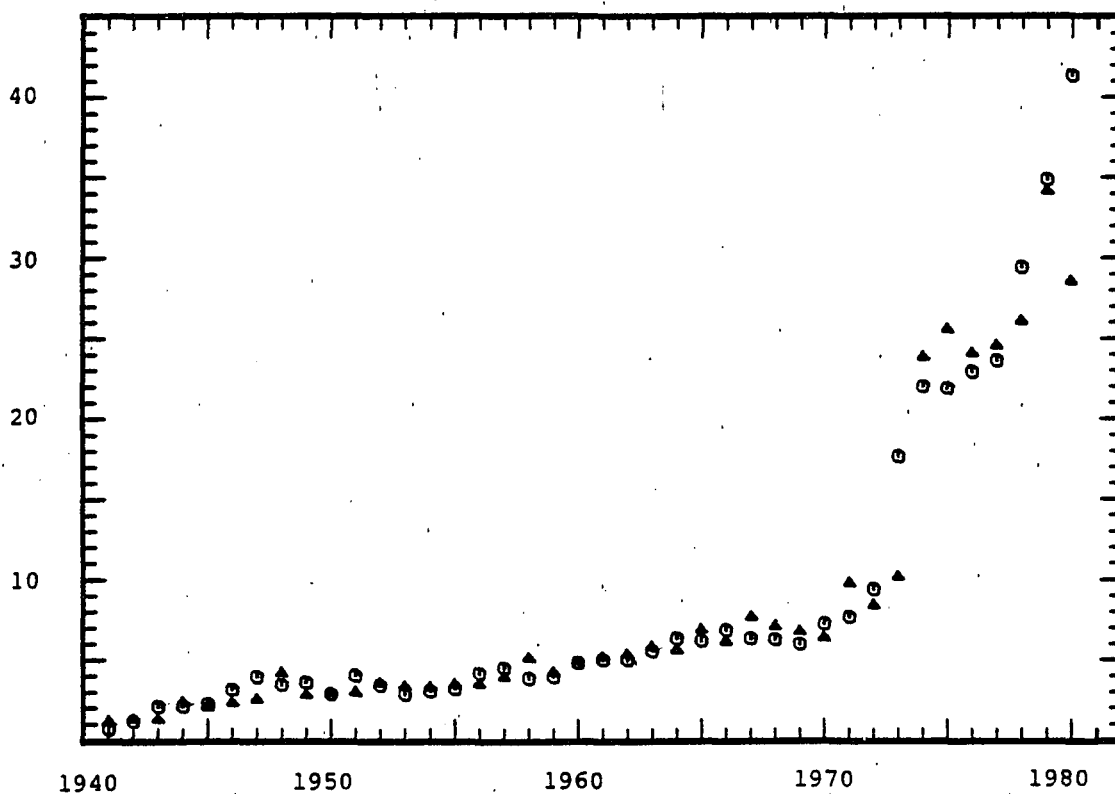


TABLE 5-4

Univariate Model Identification:
Estimated Autocorrelation Functions

5-4a

Autocorrelation Values and Standard Errors for FP

Lag	Autocorr.	St. Err.	Lag	Autocorr.	St. Err.
1	0.850	0.143	6	0.355	0.135
2	0.721	0.141	7	0.266	0.133
3	0.610	0.140	8	0.221	0.131
4	0.502	0.138	9	0.195	0.129
5	0.413	0.136	10	0.164	0.128

5-4b

Autocorrelation Values and Standard Errors for FPD1

Lag	Autocorr.	St. Err.	Lag	Autocorr.	St. Err.
1	0.738	0.144	6	0.315	0.136
2	0.570	0.143	7	0.148	0.134
3	0.570	0.141	8	0.005	0.132
4	0.414	0.139	9	0.034	0.130
5	0.328	0.138	10	0.028	0.129

5-4c

Autocorrelation Values and Standard Errors for FPD2

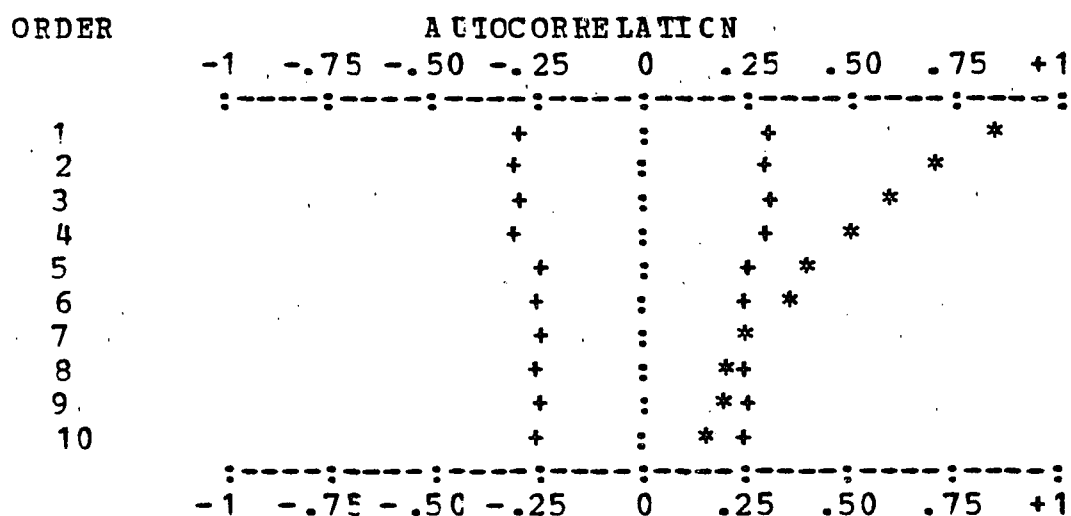
Lag	Autocorr.	St. Err.	Lag	Autocorr.	St. Err.
1	-0.205	0.146	6	0.345	0.137
2	-0.232	0.144	7	0.074	0.135
3	0.250	0.142	8	-0.020	0.133
4	-0.029	0.141	9	-0.010	0.132
5	-0.237	0.139	10	-0.027	0.130

FIGURE 5-2

UNIVARIATE MODEL IDENTIFICATION:
CORRELOGRAMS OF ESTIMATED AUTOCORRELATION FUNCTIONS

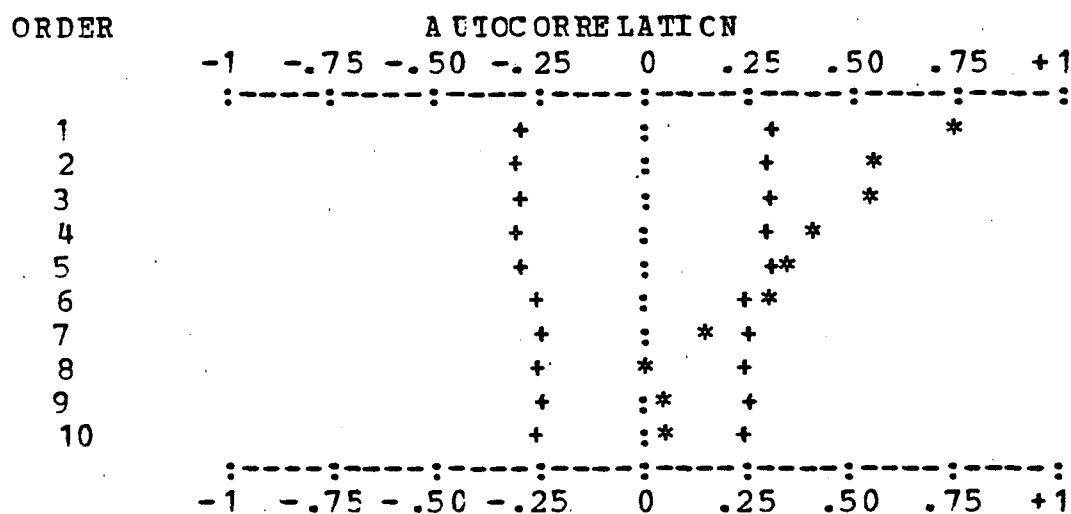
5-2 A

CORRELOGRAM OF AUTOCORRELATION VALUES WITH TWO STANDARD
 ERROR LIMITS AROUND ZERO FOR FP TIME SERIES



5-2 B

CORRELOGRAM OF AUTOCORRELATION VALUES WITH TWO STANDARD
 ERROR LIMITS AROUND ZERO FOR FPD1 TIME SERIES



* : AUTOCORRELATIONS

+ : TWO STANDARD ERROR LIMITS (APPROX.)

FIGURE 5-2 (continued)

Univariate Model Identification:
Correlograms of Estimated Autocorrelation Functions

5-2c

Correlogram of Autocorrelation Values with Two Standard
 Error
 Limits Around Zero for FPD2 Time Series

Order	Autocorrelation									
	-1	-.75	-.50	-.25	0	.25	.50	.75	+1	
	:-----:-----:-----:-----:-----:-----:-----:-----:-----:-----:									
1				+	*	:		+		
2				+	*	:		+		
3				+		:		+	*	
4				+		*	:	+		
5				+	*	:		+		
6				+		:		+	*	
7				+		:	*	+		
8				+		*		+		
9				+		*		+		
10				+		*	:	+		
	:-----:-----:-----:-----:-----:-----:-----:-----:-----:-----:									
	-1	-.75	-.50	-.25	0	.25	.50	.75	+1	

* : AUTOCORRELATIONS

+ : TWO STANDARD ERROR LIMITS (approx.)

A clue to the stationarity of a time series is whether its autocorrelations dampen to zero after a reasonable number of lags. The autocorrelation function of a non-stationary time series will fail to approach zero until autocorrelations of a higher order. Looking at table 5-4a and figure 5-2a, the autocorrelation function for FP does not dampen quickly, the autocorrelations lying outside the two standard error limit around zero until the seventh year lag [37]. The time series must be differenced to stationarity.

First-differencing the time series, FP, produces a second time series. This first differenced time series will be called FPD1. Table 5-4b and figure 5-2b contain the autocorrelation results for FPD1. The results are similar to those for FP. The autocorrelations fail to dampen until later lags, reaching the two standard error limit around zero at a lag of six years. The time series must be again first differenced to achieve stationarity.

First differencing the first differenced time series, FPD1, produces a third time series which will be called FPD2. Table 5-4c and figure 5-2c contain the autocorrelation results for FPD2.

In contrast to the autocorrelation functions of FP and FPD1, the autocorrelation function for FPD2 exhibits that of a stationary time series. Twice differencing of the original time series, FP, was necessary to achieve

stationarity. In ARIMA (P,D,Q) terminology, D is found to be 2. The choice of possible time series processes were based on the autocorrelation results for FPD2.

Viewing figure 5-2c, the autocorrelation function has a negative autocorrelation for the first and second order, after which it begins to oscillate, approaching zero. Examination of this correlogram led to the choice of two models, ARIMA (2,2,0) and ARIMA (2,2,1). The theoretical univariate models to be estimated and checked were:

ARIMA (2,2,0)

$$(16) \quad \text{FPD2}(t) = a(11)*\text{FPD2}(t-1) + a(12)*\text{FPD2}(t-2) + Z(t)$$

ARIMA (2,2,1)

$$(17) \quad \text{FPD2}(t) = a(21)*\text{FPD2}(t-1) + a(22)*\text{FPD2}(t-2) + \\ b(21)*Z(t-1) + Z(t)$$

Due to the oscillatory nature of the autocorrelation function, negative values were expected for the autoregressive parameters, $a(11)$, $a(12)$, $a(21)$ and $a(22)$, for both models, while the moving average parameter for the ARIMA (2,2,1) model, $b(21)$, was also expected to be negative due to the negative value for the autocorrelation of order 1.

Maximum likelihood estimation of the models in equations (16) and (17) produced the results found in table 5-5.

TABLE 5-5

Maximum Likelihood Results for the
Univariate Model

ARIMA (2,2,0)

$$\text{FPD2}(t) = -0.276 \cdot \text{FPD2}(t-1) - 0.365 \cdot \text{FPD2}(t-2)$$

(0.154) (0.173)

In terms of FP:

$$\text{FP}(t) = 1.724 \cdot \text{FP}(t-1) - 0.813 \cdot \text{FP}(t-2) \\ + 0.455 \cdot \text{FP}(t-3) - 0.366 \cdot \text{FP}(t-4)$$

FPD2(t-1) and FPD2(t-2) significant at the .05 level

Sum of the Squared Residuals= 1852.97
R-Squared= 0.9951
Root Mean Squared Error= 6.3468

ARIMA (2,2,1)

$$\text{FPD2}(t) = -0.619 \cdot \text{FPD2}(t-1) - 0.485 \cdot \text{FPD2}(t-2) - 0.367 \cdot Z(t-1)$$

(0.392) (0.182) (0.412)

In terms of FP:

$$\text{FP}(t) = 1.380 \cdot \text{FP}(t-1) - 0.246 \cdot \text{FP}(t-2) + 0.351 \cdot \text{FP}(t-3) \\ - 0.485 \cdot \text{FP}(t-4) + 0.368 \cdot Z(t-1)$$

FPD2(t-1) significant at the .10 level
FPD2(t-2) significant at the .05 level
Z(t-1) insignificant at the .10 level

Sum of the Squared Residuals= 1781.02
R-Squared= 0.9953
Root Mean Squared Error= 6.2224

Estimation Results

Both coefficients in the ARIMA (2,2,0) model are significant at the .05 level and were negative as expected. FPD2 was found to be explained by lagged values of itself, the lags being two years in length. The model has also been written in terms of the original time series, FP, since:

$$(18) \quad \text{FPD2}(t) = [\text{FP}(t) - \text{FP}(t-1)] - [\text{FP}(t-1) - \text{FP}(t-2)]$$

R-squareds and the sum of the squared residuals are included.

The ARIMA (2,2,1) results are similar. All coefficients are negative. The coefficient on FPD2(t-1) is only significant at the .10 level and the moving average parameter is insignificant. The sum of the squared residuals is less than that of the ARIMA (2,2,0) model, the R-squared is greater and the root mean squared error, smaller, but all by insignificant amounts. The ARIMA (2,2,1) model, however, contains an additional parameter.

Diagnostic Checking

Diagnostic checking of the two models was undertaken through analysis of the residuals of the models and the examination of the fitted time series plotted with the actual time series. The autocorrelation functions of the residuals and corresponding correlograms are found in table 5-6 and figure 5-3. The plots of the fitted and actual time

TABLE 5-6

Univariate Model Diagnostic Checking:
Estimated Autocorrelation Functions

5-6a

Autocorrelation Values and Standard Errors for
 ARIMA (2,2,0) Model Residuals

Lag	Autocorr.	St. Err.	Lag	Autocorr.	St. Err.
1	0.018	0.143	6	0.396	0.135
2	-0.003	0.141	7	0.073	0.133
3	0.089	0.140	8	-0.031	0.131
4	0.000	0.138	9	0.010	0.129
5	-0.077	0.136	10	-0.030	0.128

Box-Pierce Statistic *

B-P= 8.220 Critical Value= 15.51 (.05 level)
 Accept H_0 : residuals are white noise

5-6b

Autocorrelation Values and Standard Errors for
 ARIMA (2,2,1) Model Residuals

Lag	Autocorr.	St. Err.	Lag	Autocorr.	St. Err.
1	-0.015	0.143	6	0.382	0.135
2	0.055	0.141	7	0.052	0.133
3	-0.054	0.140	8	-0.038	0.131
4	0.041	0.138	9	0.021	0.129
5	-0.067	0.136	10	-0.037	0.128

Box-Pierce Statistic *

B-P= 7.562 Critical value= 14.07 (.05 level)
 Accept H_0 : residuals are white noise

* The Box-Pierce Statistic is distributed Chi-Square with (K-P-Q) degrees of freedom. K is the order of the autocorrelation function, and P and Q are the orders of the AR and MA processes, respectively.

FIGURE 5-3

Univariate Model Diagnostic Checking:
Correlograms of Estimated Autocorrelation Functions

5-3a

Correlogram of Autocorrelation Values with Two Standard
 Error Limits Around Zero for ARIMA (2,2,0) Model Residuals

Order	Autocorrelation								
	-1	-.75	-.50	-.25	0	.25	.50	.75	+1
	:-----:-----:-----:-----:-----:-----:-----:-----:-----:								
1				+	*	+			
2				+	*	+			
3				+	:	*	+		
4				+	*	+			
5				+	*	:	+		
6				+	:	:	+	*	
7				+	:	*	+		
8				+	*	:	+		
9				+	*	:	+		
10				+	*	:	+		
	:-----:-----:-----:-----:-----:-----:-----:-----:-----:								
	-1	-.75	-.50	-.25	0	.25	.50	.75	+1

5-3b

Correlogram of Autocorrelation Values with Two Standard
 Error Limits Around Zero for ARIMA (2,2,1) Model Residuals

Order	Autocorrelation								
	-1	-.75	-.50	-.25	0	.25	.50	.75	+1
	:-----:-----:-----:-----:-----:-----:-----:-----:-----:								
1				+	*	+			
2				+	:	*	+		
3				+	*	:	+		
4				+	:	*	+		
5				+	*	:	+		
6				+	:	:	+	*	
7				+	:	*	+		
8				+	*	:	+		
9				+	*	:	+		
10				+	*	:	+		
	:-----:-----:-----:-----:-----:-----:-----:-----:-----:								
	-1	-.75	-.50	-.25	0	.25	.50	.75	+1

* : AUTOCORRELATIONS

+ : TWO STANDARD ERROR LIMITS (approx.)

FIGURE 5-4

Actual and Fitted Values of Farmland
Prices of the ARIMA Models

ARIMA (2,2,0) Model

Actual Values ▲
Fitted Values ●

1967 = 100

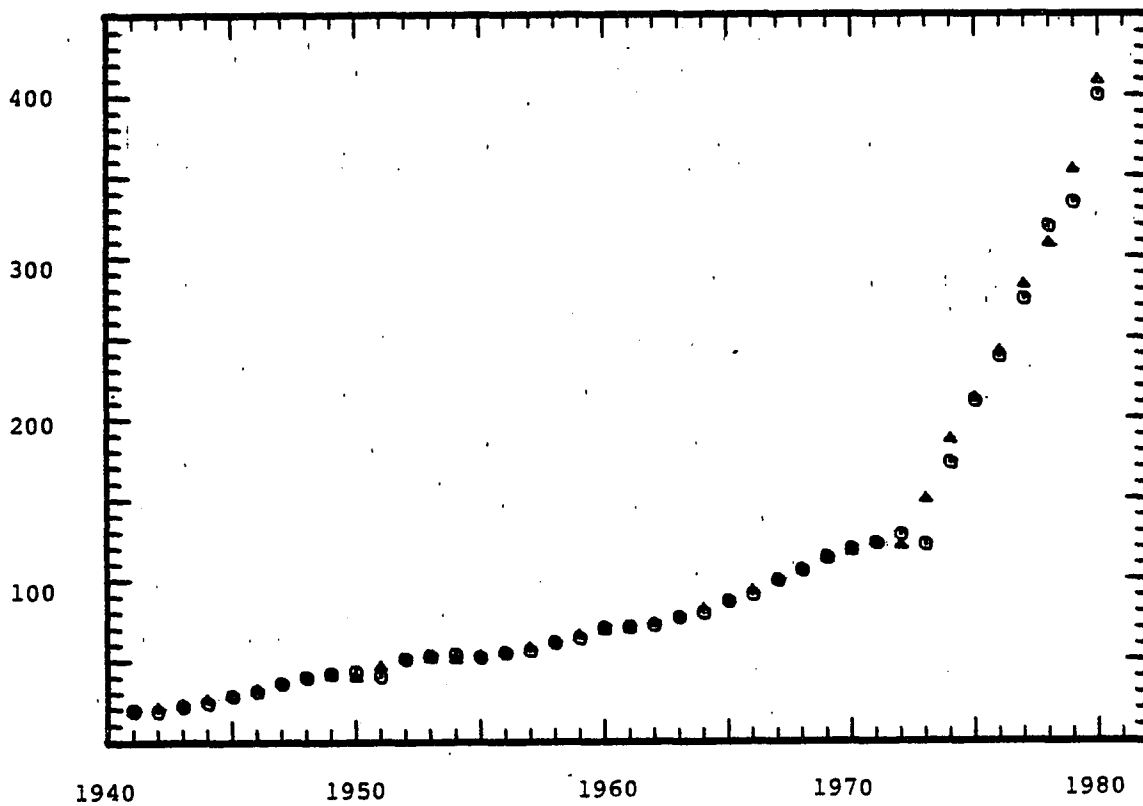


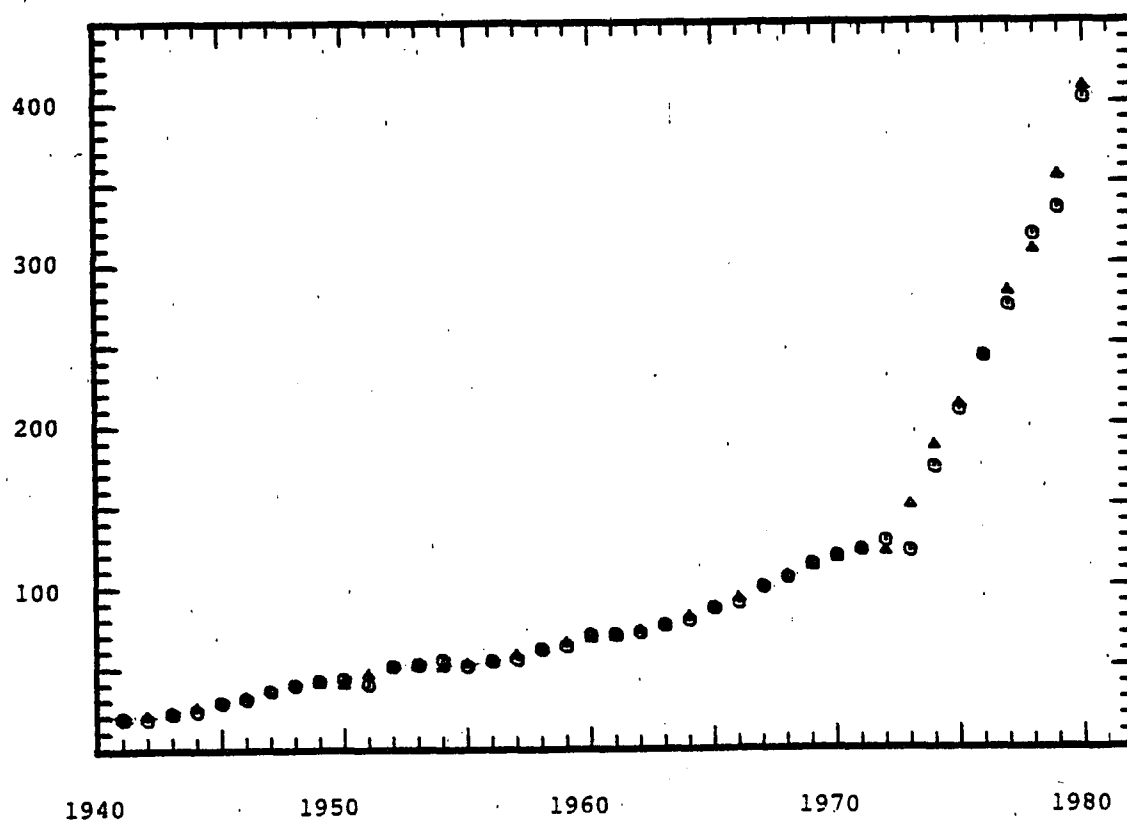
FIGURE 5-4 (CONTINUED)

Actual and Fitted Values of Farmland
Prices of the ARIMA Models

ARIMA (2,2,1) Model

Actual Values ▲
Fitted Values ●

1967 = 100



series are contained in figure 5-4.

The results are similar for the ARIMA (2,2,0) and ARIMA (2,2,1) models. The hypothesis of white noise, tested using the Box-Pierce statistic, is accepted for the residuals of both models. This means the residuals are accepted as random, serially uncorrelated disturbances. The residuals remaining after the time series is fitted to the estimated models are described by a white noise process.

One result noticeable in autocorrelations of the residuals, is the significance of the autocorrelation of order 6. This result is due, possibly, to some cycle in the data, or perhaps explained by the occurrence of the U.S. Agricultural Census undertaken every five or six years. More detailed data is collected for census years than during interim periods. This relationship between $FP(t)$ and $FP(t-6)$ is not accounted for in the models. Again, the residuals of the models were tested as white noise.

Looking at the plot of the fitted series of the models and the actual farmland price series in figure 5-4, both fitted series track the actual series well. This plot, along with the Box-Pierce statistic and autocorrelation functions for the residuals, however, fails to provide information for choice of a unique model.

The choice of a unique model in Box-Jenkins analysis, given similar results for hypothesized models, is a problem with this methodology. A common solution is to use selected tested models in the forecasting phase of the procedure. There do exist minor distinguishing characteristics between the models. A factor pointing to the choice of the ARIMA (2,2,0) specification over the ARIMA (2,2,1) model is the insignificance of the ARIMA (2,2,1) MA parameter in the estimated model. The principle of parsimony in model building, choosing the model with fewer parameters when two or more models provide similar results, also favors the choice of the ARIMA (2,2,0) model. However, since the two models produced comparable results in the diagnostic checking phase of the Box-Jenkins procedure, both models were used to forecast within and outside of sample farmland prices.

CHAPTER SIX

FORECASTING PROCEDURES AND RESULTS

Given the estimated models from Chapter Five, one, three and five year forecasts were made. The forecasting procedure is discussed first, with a description of the criteria for comparison of forecasting accuracy to follow. Finally, forecasting results are presented and discussed.

Forecasting Procedures

The Three Equation Model

Forecasts of farmland prices, net farm income and agricultural exports from the Three Equation Model were generated as follows:

- 1) The model was re-estimated for the sample period up to the year preceeding the initial year of forecasts. These sample periods are 1941 to 1979, 1941 to 1977 and 1941 to 1975, for the one, three and five year forecasts, respectively.
- 2) Actual data for the exogenous variables of the system over the forecast period was substituted into the equations and the vector of estimated coefficients of the model used to arrive at the forecasts.

These forecasts were generated using the FORCST procedure in the TSP package program. An option was used to account for the forecasts being made using a model estimated with a serial correlation correction.

The Univariate Model

The Univariate Model was identified, estimated and checked in Chapter Five. Future values of farmland prices were forecast using the ARIMA (2,2,0) and ARIMA (2,2,1) models.

The m -step forecast of a time series X from period t can be described as $X^*(t,m)$, where t is the time period from which X is forecasted and m is the number of time periods forward from t the forecast of X is made for. The forecast of 1980 farmland prices from 1979 is $FP^*(1979,1)$. The minimum mean square error forecast at time t for lead time m is the conditional expectation, given past information, of $X(t+m)$ at time t . In the estimated ARIMA models, the forecast for 1980 farmland prices at 1979 for the ARIMA (2,2,0) model is:

$$\begin{aligned}
 (19) \quad FP^*(1979,1) &= E[FP(1980) | FP(1979), FP(1978), \dots] \\
 &= 1.724*FP(1979) - 0.813*FP(1978) + 0.455*FP(1977) \\
 &\quad - 0.366*FP(1976)
 \end{aligned}$$

and for the ARIMA (2,2,1) model:

$$\begin{aligned}
 (20) \quad FP^*(1979, 1) &= E[FP(1980) | FP(1979), FP(1978), \dots] \\
 &= 1.380*FP(1979) - 0.246*FP(1978) + 0.351*FP(1977) \\
 &\quad - 0.485*FP(1976) + 0.368*Z(1979).
 \end{aligned}$$

$FP^*(1978, 2)$, $FP^*(1977, 5)$, etc., would have similar interpretations.

The ILA package program was used to generate forecasts in this manner.

Forecasting Accuracy Criterion

Root Mean Squared Error

The root mean squared prediction error (RMSE) is one measure of the relative accuracy of forecasts. In terms of forecasted and actual levels of a variable X , the RMSE is:

$$(21) \quad RMSE(I) = \sqrt{\left[(1/n) * \sum_{i=1}^n (FL(i) - AL(i))^2 \right]}$$

where, $FL(i)$ is the level forecasted for $X(t+i)$ made at time period t , or $FL(i) = X^*(t, m)$ with $i = m$, $AL(i)$ is the actual level observed for $X(t+i)$, and n is the total number of forecasts.

In terms of the percentage change forecast for a variable X , the RMSE is:

$$(22) \quad RMSE(C) = \sqrt{\left[(1/n) * \sum_{i=1}^n (FC(i) - AC(i))^2 \right]}$$

where, $FC(i)$ is the percentage change forecast for $X(t+i)$ made at time period t , or $FC(i) = [(FL(i) - AL(i-1)) / (AL(i-1))]$, $AC(i)$ is the actual percentage change observed from $X(t+i-1)$ to $X(t+i)$, or $AC(i) = [(AL(i) - AL(i-1)) / (AL(i-1))]$, and n is the total number of forecasts.

For the percentage change forecast, the base period for the percentage change is always the actual observed value from the previous period, rather than the value forecasted for the previous period.

Theil's Inequality or U-Coefficient

Theil's inequality or U-Coefficient is a measure of the accuracy of any given forecast model relative to the accuracy of the "no-change" forecast model. This accuracy is in terms of RMSE. The no-change forecast model assumes the forecast for the next period is equal to the present period's value. The percentage change forecasted is zero. In terms of the equation to measure RMSE for the percentage change forecast, $FC(i)=0$, for all i . The $RMSE(C)$ for the no-change forecast model is then:

$$(23) \quad RMSE(C) = \sqrt{\left[(1/n) * \sum_{i=1}^n (AC(i))^2 \right]}$$

Theil's U-Coefficient is the RMSE(C) of the forecasting model in question over the RMSE(C) for the no-change forecasting model.

$$(24) \quad U = \sqrt{\frac{\left[(1/n) * \sum_{i=1}^n (FC(i) - AC(i))^2 \right]}{\left[(1/n) * \sum_{i=1}^n (AC(i))^2 \right]}}$$

In interpreting U, four cases exist:

- 1) $U = 0$, the model predicts perfectly, $FC(i) = AC(i)$, for all i .
- 2) $0 < U < 1$, the model forecasts more accurately than the no-change forecast model, in terms of RMSE(C).
- 3) $U = 1$, the model predicts equally as accurate as the no-change forecast model, in terms of RMSE(C).
- 4) $U > 1$, the no-change forecast model "out-forecasts" the model in question.

The U-Coefficient measures the accuracy of the forecasting model versus that of the no-change forecast model. Accuracy is measured in terms of RMSE(C) over the forecast period.

Theil's Inequality Proportions

Theil's inequality proportions measure the types of error that contribute to the inaccuracy of the forecast model. A description of the U-proportions follows.

By algebraic manipulation of the numerator of (24), squared, followed by division by this squared numerator, the following equation is derived

$$\begin{aligned}
 (25) \quad 1 = & \frac{[\text{Mean}(\text{FC}) - \text{Mean}(\text{AC})]^2}{(1/n) * \sum_{i=1}^n (\text{FC}(i) - \text{AC}(i))^2} + \frac{[\text{SDev}(\text{FC}) - \text{SDev}(\text{AC})]^2}{(1/n) * \sum_{i=1}^n (\text{FC}(i) - \text{AC}(i))^2} \\
 & + \frac{2*[1 - \text{Corr}(\text{FC}, \text{AC})] * \text{Var}(\text{FC}) * \text{Var}(\text{AC})}{(1/n) * \sum_{i=1}^n (\text{FC}(i) - \text{AC}(i))^2}
 \end{aligned}$$

where, $\text{Mean}(X)$ is the mean of X , $\text{SDev}(X)$ is the standard deviation of X , $\text{Var}(X)$ is the variance of X , and $\text{Corr}(X, Y)$ is the correlation coefficient for X and Y [38].

The three terms on the right-hand side of (25) are the bias proportion, $U(m)$, variance proportion, $U(s)$, and the covariance proportion, $U(c)$, respectively. Each of these components may be interpreted in terms of the source of the forecast inaccuracy of the predictive model.

$U(m)$, the bias proportion, measures that proportion of predictive error due to the difference between the average forecasted change and the average actual change. $U(m)$ would be expected to be relatively smaller than the other components, particularly as n , the length of the forecast period, increases, the forecasted percentage changes and the actual percentage changes averaging out. If $U(m)$ is not

small, it may be possible to reduce $U(m)$ through modification of the model. It is not certain however, that a decrease in $U(m)$, at the expense of $U(s)$ and $U(c)$, will result in an overall increase in the predictive accuracy of the model.

$U(s)$, the variance proportion, measures that proportion of the predictive error due to the difference between the standard deviations of FC and AC. Assuming the actual values are generated by systematic changes and random changes, and in forecasting future values an attempt is made to capture a portion of the systematic changes, $SDev(AC)$ would be expected to be greater than $SDev(FC)$. As more systematic changes are modelled, $SDev(AC) - SDev(FC)$ will decrease. It may occur that $SDev(FC) > SDev(AC)$. This could be a result of making a model too complex [39].

$U(m)$ and $U(s)$ are proportions of the predictive error that might be decreased through modification of the model. Care should be taken in decreasing one proportion while increasing the other two that overall model accuracy is not decreased.

$U(c)$, the covariance proportion, decreases as the correlation coefficient for FC and AC approaches 1. $Corr(FC, AC) = 1$ would occur if the forecasted percentage change and actual percentage change were experiencing parallel movement. A plot of FC and AC would be a straight line. It is not probable that this situation will occur.

Where it may be possible to decrease $U(m)$ or $U(s)$ by modification of the predictive model, the covariance inequality proportion, $U(c)$, is not under the model builder's control [40].

Forecasting Results

Farmland Prices

Five Period Forecasts. The five period farmland price forecasting results are contained in Table 6-1. The Three Equation and ARIMA (2,2,0) models perform well and provide superior level and percentage change forecasts to the ARIMA (2,2,1) model based on RMSE and U-coefficients. The Three Equation Model generates forecasts close to actual levels for 1977 to 1979, but its predictions are low for the years 1976 and 1980. The ARIMA (2,2,0) model forecasts well for 1976 and 1977 but its forecasts are low for the final three years of the forecast period. The ARIMA (2,2,1) model's five period forecasts all lie well below the actual levels of farmland prices. The inclusion of the first order MA parameter in this model did not result in an improved forecasting performance over that of the ARIMA (2,2,0) model.

The results of all models generating farmland price forecasts below the actual levels is interesting. This result indicates that farmland prices were increasing at levels above those warranted by the values of variables historically influencing them, over the forecast period.

TABLE 6-1

Farmland Price Forecasts

Year	Actual	Forecast 3QM	Forecast (2,2,0)	Forecast (2,2,1)
<u>Five Period Forecast</u> (1976 to 1980)				
(level forecasted)				
1976	241.5	220.8	235.4	226.7
1977	282.6	276.2	262.7	238.9
1978	308.3	296.3	290.8	255.0
1979	354.2	334.0	317.4	274.3
1980	409.1	372.8	343.6	293.8
(percentage change forecasted *)				
1976	+13.70	+ 3.93	+10.77	+ 6.73
1977	+16.97	+14.37	+ 8.77	- 1.08
1978	+ 9.09	+ 4.88	+ 2.90	- 9.77
1979	+15.02	+ 8.38	+ 2.95	-11.02
1980	+15.55	+ 5.25	- 2.99	-17.05
<u>Three Period Forecast</u> (1978 to 1980)				
(level forecasted)				
1978	308.3	299.3	321.2	320.5
1979	354.2	338.2	355.3	354.1
1980	409.1	384.8	390.6	390.2
(percentage change forecasted *)				
1978	+ 9.09	+ 5.94	+13.60	+13.41
1979	+15.02	+ 9.75	+15.24	+14.86
1980	+15.55	+ 8.62	+10.27	+10.17
<u>One Period Forecast</u> (1980)				
1980	409.1	392.2	396.9	399.0

* Percentage change forecasted (t) =

[forecast (t) - actual (t-1)] / actual (t-1)

3QM = Three Equation Model

(2,2,0) = ARIMA (2,2,0) Model

(2,2,1) = ARIMA (2,2,1) Model

Expectations of each year's farmland price increase to continue or grow the following year could be responsible. An attempt to account for these expectations was made through inclusion of the lagged weighted average variable, real capital gains, in the Farmland Price Equation. Farmland price increases for each year, however, are above those forecasted with each of the three models. Farmland price levels may be due for a correction in coming years. This has been alluded to by farmland price behavior in 1981, as discussed in Chapter Two.

The accuracy analysis results, found in Table 6-2, support the superiority of the Three Equation and ARIMA (2,2,0) models' forecasting ability over that of the ARIMA (2,2,1) model for the five period farmland price forecasts. The Three Equation Model is found to outperform the ARIMA models in terms of RMSE's and Theil's U-Coefficient for the percentage change forecast. The RMSE(L) and RMSE(C) for the Three Equation Model are lower than those for the ARIMA (2,2,0) and one-third those for the ARIMA (2,2,1) forecasts. The U-Coefficients for the Three Equation and ARIMA (2,2,0) models, 0.512 and 0.761, respectively, are less than 1. This indicates the models generated more accurate five period percentage change forecasts than the no-change forecast model. The U-Coefficient for the ARIMA (2,2,1) model, 1.553, points to the superiority of the no-change forecast model over it in terms of forecasting accuracy.

TABLE 6-2

Farmland Price Forecasts
Accuracy Analysis

****Root Mean Squared Error****

Periods	Level			% Change		
	Three Eq. M.	ARIMA (2,2,0)	ARIMA (2,2,1)	Three Eq. M.	ARIMA (2,2,0)	ARIMA (2,2,1)
5	21.58	35.73	70.21	7.34	10.91	22.23
3	17.68	13.04	12.99	5.32	4.01	3.98

****Theil's Inequality Coefficient U for % Change Forecast****

Periods	Three Eq. M.	ARIMA (2,2,0)	ARIMA (2,2,1)
5	0.512	0.761	1.553
3	0.393	0.296	0.293

****Breakdown for Theil's U-Coefficient****

Coefficient	Three Eq. M.	ARIMA (2,2,0)	ARIMA (2,2,1)
-------------	-----------------	------------------	------------------

Five-Period Forecasts

U(m)	0.831	0.771	0.851
U(s)	0.023	0.039	0.064
U(c)	0.146	0.200	0.085

Three-Period Forecasts

U(m)	0.926	0.002	0.011
U(s)	0.063	0.045	0.059
U(c)	0.011	0.953	0.933

The breakdowns for Theil's U-Coefficient, the bias, variance and covariance proportions, are found in Table 6-2. These proportions provide information concerning the source of the inaccuracy in the percentage change forecasts of the models. In each of the models the bias proportion, $U(m)$, is responsible for the majority of the inaccuracy. $U(m)$ is 83, 77 and 85 percent for the five period percentage change forecasts of the Three Equation, ARIMA (2,2,0) and ARIMA (2,2,1) models, respectively. $U(s)$ and $U(c)$, the variance and covariance proportions, contain lesser amounts.

The large percentage made up by the bias proportion is due to all forecasts being low for the five periods for each model. Inclusion of an additional variable in the Three Equation Model, possibly one to more completely gauge expectations, may decrease $U(m)$. Whether the forecasting accuracy, as measured by U , would improve is uncertain at this time. Modification of the ARIMA models is not necessary as they are correct for the estimation sample period, 1941 to 1975, for the five period forecasts. Estimation over a longer sample period such as for the one and three period forecasts should produce improved results as additional data from the period of more rapidly increasing farmland prices, 1973 to 1980, are included.

Three-Period Forecasts. The three period farmland price forecasts are found in Table 6-1. In contrast to the five period forecasts, the ARIMA models' forecasts are

superior to those of the Three Equation Model, based on RMSE and U-coefficients. The Three Equation Model forecasts well for 1978 to 1980 but its predictions are below the actual values for all three years. The ARIMA models' forecasts are close to actual values for all three periods, particularly the final two years, better catching the upswing in 1980 than the Three Equation Model or any of the three models in the five period forecasts. The farmland price forecasts of the ARIMA (2,2,1) model are greatly improved over the model's five period performance.

The accuracy analysis results, found in Table 6-2, show the ARIMA models to be the superior forecasting models for the three period predictions. RMSE(L) and RMSE(C) for the Three Equation Model are higher than those for the ARIMA forecasts. All U-Coefficients are below 1, meaning the three models generate more accurate forecasts than the no-change forecast model. The ARIMA models have U-Coefficients closer to zero than the Three Equation Model.

The inequality proportions for the U-Coefficient are improved over those for the five period forecasts for the ARIMA models, with U(m) and U(s) summing to only 4.7 and 7.0 percent for the ARIMA (2,2,0) and ARIMA (2,2,1) models, respectively. A large percentage of the inaccuracy of the three period percentage change forecasts of farmland prices generated by the ARIMA models is found in the covariance proportion, U(c). The U-proportions for the Three Equation

Model forecasts are similiar, with a good percentage of the inaccuracy of the predictions being due to $U(m)$.

The ARIMA models outperformed the Three Equation Model over the shorter forecast period, the opposite being true for the five period forecasts. This result is a common finding of economic studies comparing the predictive accuracy of a univariate and a simultaneous equation forecast model over different lengths of forecast period [41]. ARIMA models have been found to have superior forecasting ability to that of simultaneous equation models over shorter forecast periods. Simultaneous models have been found to have a predictive edge over longer forecast periods.

One-Period-Forecasts. The one period forecasts are found in Table 6-1. The ARIMA models produce more accurate forecasts of farmland prices for 1980. All three models generate predictions closer to the actual levels than produced in the longer forecasting period lengths.

Five-Period-ARIMA-Future-Forecasts. Five period future farmland price forecasts were generated using the ARIMA models. The results are contained in Table 6-3 below.

TABLE 6-3

Future ARIMA Farmland Price Forecasts

Year	ARIMA (2,2,0)		ARIMA (2,2,1)	
	Level	% Increase	Level	% Increase
1981	454.5	11.1	451.4	10.3
1982	499.0	9.8	497.3	10.2
1983	547.4	9.7	547.1	10.0
1984	594.9	8.7	592.6	8.3
1985	641.3	7.8	638.8	7.8

The models forecast continuing farmland price increases to 1985. The percentage increase, however, decreases into the future. The ARIMA models produce similar results over all five periods, both predicting a 7.8 percent increase from 1984 levels to those of 1985.

Net Farm Income and Agricultural Export Forecasts

Five Period Forecasts. Net farm income and agricultural exports forecasts were generated using the Three Equation Model. The forecast results are found in Table 6-4 and the accuracy analysis results, in Table 6-5.

Looking at Table 6-4, although the NFI and EXT forecasts are close to the actual values for selected years; 1976 and 1967 for NFI and EXT five period forecasts, 1980 for the NFI three period forecasts, and 1980 for the NFI one period forecast, the results are not comparable with the farmland price predictions.

TABLE 6-4

Net Farm Income and Agricultural Exports Forecasts
From the Three Equation Model

Year	Actual Level	Level Forecast	Actual % Change	% Change Forecast *
<u>Five-Period Forecast</u> (1976 to 1980)				
Net Farm Income (millions of \$)				
1976	18676.1	21437.0	-23.28	-11.89
1977	20475.8	19279.6	+ 9.63	+ 3.22
1978	28001.1	22690.4	+36.75	+10.85
1979	30946.0	26165.9	+10.52	- 6.15
1980	23388.5	19385.7	-24.42	-37.06
Agricultural Exports (millions of \$)				
1976	22997.0	22629.8	+ 5.09	+ 3.41
1977	23636.0	22878.6	+ 2.78	- 0.51
1978	29384.0	23913.3	+24.32	+ 1.17
1979	34575.0	27731.9	+18.24	- 5.62
1980	41256.0	23078.9	+18.74	-33.58
<u>Three-Period Forecast</u> (1978 to 1980)				
Net Farm Income (millions of \$)				
1978	28001.1	23576.4	+36.75	+15.18
1979	30946.0	26606.2	+10.52	- 4.56
1980	23388.5	19923.2	-24.42	-35.31
Agricultural Exports (millions of \$)				
1978	29384.0	24562.0	+24.32	+ 3.92
1979	34745.0	28381.5	+18.24	- 3.41
1980	41256.0	23535.6	+18.74	-32.26
<u>One-Period Forecast</u> (1980)				
1980	23388.5	22569.3	41256.0	28567.9

* Percentage change forecasted(t) =
 [forecast(t)-actual(t-1)] / actual(t-1)

TABLE 6-5

Net Farm Income and Agricultural Exports Forecasts
Accuracy Analysis

****Root Mean Squared Error****

	Level		% Change	
Periods	Net Farm Income	Agric. Exports	Net Farm Income	Agric. Exports
5	3902.0	9057.8	15.86	27.77
3	4008.2	11220.0	16.29	34.09

****Theil's Inequality Coefficient U for % Change Forecast****

Periods	Net Farm Income	Agric. Exports
5	0.683	1.72
3	0.62	1.65

****Breakdown for Theil's U-Coefficient****

Coefficient	Net Farm Income	Agric. Exports
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Five Period Forecasts

U (m)	0.398	0.564
U (s)	0.166	0.035
U (c)	0.436	0.401

Three Period Forecasts

U (m)	0.939	0.828
U (s)	0.057	0.142
U (c)	0.004	0.030

Except for one forecast, the NFI level forecasts are consistently below the actual NFI levels. The model does however predict the downturn in 1976 and overforecasts but predicts the downturn for 1980. The accuracy analysis results for NFI show relatively high RMSE(L) and RMSE(C) for the forecasts. Both U-Coefficients, 0.68 and 0.62 for the five and three period NFI percentage change forecasts, respectively, are smaller than 1. The model predicts better than the no-change forecast model over these time periods. The bias proportion, $U(m)$, is high for the three period forecasts, due to the underforecasting by the model for all three years.

The EXT forecast results are poor. The model does predict well for selected years, 1976 and 1977, but overall fails to capture the changes in the value of agricultural exports. The model incorrectly forecasts downturns in 1979 and 1980, and underforecasts the EXT value increase for 1978. The accuracy analysis results for the EXT forecasts show U-Coefficients of 1.72 and 1.65 for the five and three period forecasts, respectively. Both U-Coefficients are above 1. The RMSE(L) and RMSE(C) are similar for the five and three period results.

Summary of Forecasting Results

The major forecasting results were:

- 1) The Three Equation Model generated superior five year farmland price forecasts, compared to those of the

ARIMA models, in terms of root mean squared error and Theil's inequality coefficient.

- 2) The ARIMA models generated superior three year farmland price forecasts, compared to those of the Three Equation Model, in terms of root mean squared error and Theil's inequality coefficient.
- 3) The majority of farmland price forecasts from the Three Equation and ARIMA models were below actual levels for all forecast periods.
- 4) With the exception of the ARIMA (2,2,1) five year forecasts, the models provided forecasts superior to those of the "no-change" forecast model.
- 5) The Three Equation Model generated net farm income forecasts superior to those of the "no-change" forecast model for all forecast periods.
- 6) The Three Equation Model generated U.S. agricultural exports predictions inferior to those of the "no-change" forecast model for all forecast periods.

CHAPTER SEVEN

SUMMARY AND CONCLUSIONS, POLICY IMPLICATIONS, AND FURTHER RESEARCH

Summary and Conclusions

A three equation econometric model consisting of a Farmland Price, Net Farm Income and Agricultural Exports equation was developed. Hypotheses of factors influencing the independent variables were tested by estimation of the simultaneous equation system. A first order serial correlation correction was necessary to obtain consistent estimates of the coefficients in each of the equations.

Factors found to directly influence farmland prices included net farm income, agricultural exports and expected real capital gains from farm real estate. Government payments divided by cash receipts, the USDA parity price ratio and alternative investment returns were found to have an inverse relationship with average farmland values.

The finding of net returns to farming and real capital gains being important in explaining farmland price movements is consistent with the conclusions of earlier studies. These earlier studies found returns to farming and gains from farmland price appreciation to be determinants of

average agricultural land values. Returns to the production asset, in the form of income or capital gains, are important in the valuation of that asset.

The significance of U.S. agricultural exports and alternative investment returns, as measured by real stock prices, in the Land Price Equation is important. The increase in foreign marketings of U.S. agricultural products has resulted in the bidding up of farmland values. The percentage of cropland used in production for export as well as the total amount of agricultural land employed in production for export, has risen. The increase in agricultural exports has provided expanded markets for U.S. farmers. Agricultural exports influence farmland prices through farm expansion.

Farmland prices have also been pushed upward by the purchase of agricultural land for investment. The relatively higher return from farmland ownership compared to owning stocks over the last two decades has been responsible for this. This result is consistent with the conclusions of portfolio analyses which found farmland to be an alternative investment to stocks based on its relative return and risk. The Farmland Price Equation explained more than 99 percent of the variation in farmland prices over the estimation period 1941 to 1980.

Estimation of the Net Farm Income Equation found direct government payments, the USDA parity price ratio, the USDA production index and the value of agricultural exports to directly influence net farm returns.

The price and quantity variables, the parity price ratio and the production index, were important in explaining net returns to farming. The unfavorable prices received to prices paid ratio farmers have faced in recent years and low years of production explain the lower current levels of net farm income relative to the levels of the mid-1970's. The value for the estimated coefficient on direct government payments, 0.06, gives little weight to current government payments to farmers in influencing current net farm income. The positive coefficient on agricultural exports shows the influence of foreign marketings U.S. farm produce on net farm income. Agricultural exports influence farmland prices directly through expansion of landholdings, as found in the Farmland Price Equation, and through net farm income in this equation. This equation accounted for 89 percent of the variation in net farm income over the estimation period.

The USDA production index and a dummy variable for 1974 to 1980, a period of increase in the value of imported energy, were found to directly influence U.S. agricultural exports. The index of total farm production being significant implies an existing import demand for excess U.S. farm output. In high years of U.S. agricultural

output the relative value of farm exports rises. Increased output supplies a surplus for export, satisfying a portion of world food import requirements.

The dummy variable in the exports equation shows the impact of the balance of trade deficits from the sharp increase in the value of imported energy on U.S. farm exports. The promotion of foreign marketings of U.S. agricultural output through subsidies, access to new markets, or lowering trade barriers, was a measure chosen to offset this trade deficit. The independent variables in this equation were found to explain 90 percent of the variation in U.S. agricultural exports over the sample period.

Two univariate ARIMA farmland price forecasting models were developed. Forecasts of farmland prices were made using the Three Equation Model and the two ARIMA models. Although the Three Equation model outforecast the ARIMA models over a five year forecast period, the ARIMA models provided superior predictions for the shorter forecast periods of one and three years. This result of ARIMA models outperforming a simultaneous equation model over the shorter forecast period and the opposite being true for the longer forecast period supports the findings of other studies comparing the predictive ability of univariate forecasting models versus larger models over forecast periods of different length.

The farmland price forecasts generated by the three models were close to actual values for a majority of the years. All forecasts, however, were below actual values.

This result of farmland price predictions being below actual values may provide information about farmland price behavior of the immediate future. Farmland prices are increasing at levels above those warranted by factors hypothesized to determine them. Expectations of continued large capital gains from farm real estate may be responsible. A correction downward in the rate of farmland price inflation is expected. As was indicated above, average U.S. farmland values per acre increased by only one percent during 1981. This increase follows increases of 15 percent for 1979 and 1980.

Five years of future values of farmland prices were forecasted using the ARIMA models. Average farmland values were predicted to increase at a decreasing rate over the period 1981 to 1985. The forecast of a ten percent increase during 1981 is above the observed increase of one percent.

Forecasts of net farm income and agricultural exports were also generated with the three equation model. Net farm income forecasts were well below actual levels for the majority of the years. The model predicted agricultural exports values close to actual values for some years but predicted poorly for others.

Implications and Policy Prescriptions

Some of the implications of rapidly rising farmland prices were discussed in Chapter Two. These included: 1) altering the structure of American agriculture through concentration of land holdings and the creation of barriers to entry by new farmers, 2) increases in debt through leveraging, resulting in a debt structure dependent upon a favorable farm income situation, low and stable mortgage rates and continuing land price increases, and 3) speculation in farm real estate resulting in productive farmland coming under the control of non-farmers.

This study found farmland price movements to be linked to changes in current income from farming, real capital gains from farm real estate, agricultural exports and alternative investment returns. Policy measures are offered below with these findings in mind.

The variability in current farm returns could be a target for policy. Government actions aimed at the farm income situation are usually designed to soften the effects of a "trough" in the current farm returns picture. Peaks in the returns cycle are not truncated as the low points are. A policy which decreased the short run variability of net farm returns could be useful in controlling sharp land price increases. The recent "boom" years in farm income, 1973 and 1974, coincided with years of sharp increases in farmland prices. These favorable farm income years also fueled

expectations of similiar future income and land price gains.

Examples of policies which would decrease the variability of net farm income and its effect on farmland prices are easing crop support programs in the face of high price or demand years and lowering payments tied to farmland. The latter suggestion would be difficult to implement. Most government farm programs are either directly or indirectly tied to farmland. A further measure which would decrease the variability in net farm returns and its effect on farmland price inflation is to design the programs influencing farm income to be of a long term nature in comparison to shorter term, near sighted proposals. Current policies designed to increase short term returns in an area of production often require further future intervention to correct the undesired side effects of the program.

Taxes are a tool that can be used to influence farmland prices and the farmland ownership structure. Capital gains taxes are one example. Capital gains are currently taxed at rates lower than current income. There also exist exemptions which make the acquisition of assets for use as a store of value, such as farmland, more appealing. Lower rates on capital gains are designed to promote investment and productivity, and increase the national wealth. Investment in farmland is primarily an investment in an existing asset. Productivity is not neccessarily enhanced

and total wealth is not increased with price appreciation of an existing asset. Tax rates on capital gains from farm real estate could be increased to bring them more in line with those on current returns. The tax structure could be designed to discourage the use of farmland as a store of wealth. The increased taxing of farmland capital gains could also control false expectations leading to farmland prices above warranted levels.

Another form of taxes exists which is presently used to influence farmland ownership and prices. These are inheritance, gift and estate taxes. Under the Special Use Valuation provisions [Internal Revenue Code §2032A], farm operations with family farm organizational characteristics are valued at agricultural use for taxation purposes upon estate transfer. Specifications require the farm to have been worked by the owners or heirs in the recent past. The heirs must also continue to farm the land for ten years after transfer. This tax exemption discriminates against owners of farmland as a store for use as a store of value. Land transfers in these categories not qualifying for the exemption are taxed at market rather than agricultural value. These exemptions could be expanded to facilitate transfer of an estate to unrelated entry level farmers. The increase in incorporation of farms, however, limits the value of this measure. Corporate assets are not subject to the type of taxation that estates are.

Property taxes are a policy tool available for controlling farmland prices. Increasing property taxes could decrease returns to land and cut into capital gains. These taxes could be designed to allow exemptions in poor income years or allow exemptions to owner operators or new entrants into farming. Property taxes could promote smaller farms, a larger distribution of ownership and decreases in absentee, non-farmer ownership.

An aspect of taxation policies which furthers their appeal is the ability to target them to achieve certain results. Care should be taken so short sighted policies do not result in longer run problems, as discussed above.

In addition to tax programs, policies exist which would promote desired characteristics of farm ownership structure, such as increased new entrants, decreased concentration and a larger percentage of owner operators. Limiting the use of farmland as a means to leverage further purchases through the control of debt to equity ratios is one example. Use value assessment designed to restrict the purchase and holding of farm real estate for speculative purposes is another option. This measure would also provide an incentive to keep land in agricultural use.

Policies designed to aid new entrants into farming could include subsidizing mortgages on initial purchases of farm real estate or providing a pool of funds for short term loans to ease cash flow difficulties in early years of

farming. Government programs could also be aimed at medium sized established farmers. Subsidizing the very small farmer may require raising prices above target levels, while supporting the larger farmers allows them to grow larger and continue expansion. Exceptions could be made for new, smaller operations.

Some suggestions to solve the farmland price and farmland ownership structure problems of a radical nature have been offered [Reinsel and Reinsel (1979) and Plaxico (1979)]. One such measure is to create a public trust authority which holds title to all farmland. Agricultural land could be leased to farm-operators, including corporations, on a long term basis. A planning horizon of thirty years has been suggested. The trust authority could be financed by investors in a way similar to public utilities. Rates of return could also be controlled. In this manner concentration of ownership, high land price inflation, capital gains and over accumulation of debt would be eliminated. Steps could be taken to insure an influx of new entrants into farming and control the size of holdings so an equitable distribution could be reached. The severity of a measure to provide a trust with a monopoly on farmland ownership to remedy the problem, however, may make this solution politically unacceptable.

Further Research

An area to pursue for future farmland price research concerns the units chosen for analysis. Current time series models of U.S. farmland prices, including this study, assume a national market for farmland [42]. Data at the national level is used and aggregation problems ignored. Regional differences in crops, technology, urbanization and land market behavior exist and are often lost with the assumption of a national market. Current data availability prohibits regional analyses of farmland prices. Data series for exports, parity prices and pre-1949 net farm income do not exist at the state or production region level. Regional or state analyses of farmland prices would provide insights into farmland price behavior which are lost in the aggregation problems of national land market models.

In the area of forecasting farmland prices, future studies could employ newer techniques in predicting time series. Two of these procedures are state space forecasting and vector-autoregression [43]. State space employs a multivariate ARIMA structure, where future values are forecast using past knowledge from the time series to be forecast and past information from variables found to be important in providing forecasts of the time series. State space forecasting originates primarily from work by control engineers in systems identification. Using an information criterion, state space provides automatic identification of

a time series forecasting model. Vector autoregression uses only autoregressive (AR) parameters and may be used to find policy multipliers for variables of a system, in addition to generating forecasts. All variables are treated as endogenous in vector autoregression. These two procedures could supply improved forecasts of farmland prices.

Another possibility for future study is to incorporate a farmland price model into a rational expectations framework [44]. Rational expectations theorists believe that economic actors form expectations rationally and anticipate future environments when making current decisions. Rational expectations models tie coefficients in equations of economic agents behavior to coefficients in equations describing certain policy rules. The coefficients of the behavioral equations are restricted by the coefficients of the policy rule equations. These are called the cross-equation restrictions. Optimal decision rules include variables that influence the environment the agents believe they are operating in. Changes in the structure of farming, agricultural land ownership, farm programs and the relationship between the farm sector and non-farm sector over time suggest rational expectations may be appropriate in modelling farmland and the farm sector.

Additional research areas to pursue are examination of:

- 1) the effect of current trends in farmland ownership on farmland prices, 2) the influence on farmland prices of

different measures currently used to retain land in agricultural uses, and 3) the implications of the current problem of cropland erosion on future farmland ownership, ownership responsibility and prices.

REFERENCE NOTES

[1] Source: Balance Sheet of the Farming Sector, various years.

[2] Source: Balance Sheet of the Farming Sector, various years.

[3] Other long-term assets exist in agriculture, but none have experienced the price appreciation that farmland has.

[4] Source: Farm Real Estate Market Developments, various years.

[5] Source: Federal Reserve Bulletin, December, 1980.

[6] Source: Farm Real Estate Market Developments, August, 1981.

[7] Congress has shown interest in influencing the structure of farming towards small to medium family farms in past and recent legislation. Recent bills include: 1) The Family Farm Act of 1972; 2) The Family Farm Antitrust Act of 1975; and 3) an ammendment to the Food and Agricultural Act of 1977 which limits participation in farm programs to farm operations organized in specific ways [Boles and Rupnow (1978)].

[8] Source Agricultural Statistics, various years.

[9] Source: Agricultural Statistics, various years.

[10] Source: U.S. General Accounting Office (1980) .

[11] Source: Farm Real Estate Market Developments, various years.

[12] Source: U.S. General Accounting Office (1980) .

[13] Although fcreign investment in farm real estate has not been extensive [Luttrell (1979)], it has become an emotional issue for some. Recent legislation shows Congress' interest in the subject [Foreign Investment Study Act of 1974 and International Investment Survey Act of 1976].

[14] Source: Boles and Rupnow (1978), p. 469. The testimony was given before the Senate Subcommittee on Monopoly, of the Select Committee on Small Business on the Role of Giant Corporations in the American and World Economies, Part 8 Corporate Secrecy: Agribusiness, 93rd Congress, March 1, 1973.

[15] Source: Farm Real Estate Market Developments, August, 1979.

[16] See Scott (1982) and Farm Real Estate Market Developments, August 1982.

[17] See The Wall Street Journal, March 11, 1982.

[18] Taking the natural log of an equation in multiplicative form allows the estimation of the equation in a linear form, linear in parameters.

[19] For convenience, the term "gains" represents both gains and losses.

[20] Criterion used for choice of lag length and weighting scheme included significance of the estimated variable and results of previous research, such as Kuhlman (1977). The weight for each lag is 0.5^{*L} , where L equals the lag length. L equals 1, 2, ..., 6.

[21] See Talbot (1979).

[22] Source: Agricultural Statistics, various years.

[23] Law requires the publication of the parity price ratio using the base years 1910-1914. Other base years used are 1949 and 1967. A base period of 1949 was used for this study, unless otherwise indicated.

[24] The USDA index of productivity, the index of output per unit of input, grew at an annual compound rate of 1.9 percent between 1945 and 1965. In contrast, the index grew at an annual compound rate of 1.1 percent over the period 1965 to 1980. Source: Agricultural Statistics, various years.

[25] Source: U.S. General Accounting Office (1980).

[26] For a further discussion of the interpretation of the USDA parity price ratio, see U.S. General Accounting Office (1980).

[27] Source: Agricultural Statistics, various years.

[28] For a discussion of the Instrumental Variables Technique see Intrilligator (1978), p. 394 - 402.

[29] The Time Series Processor (TSP) package program, version 3.5, was used for this portion of the study. The DEC-10 computer at the University of New Hampshire was utilized for all computations in this study.

[30] A white noise process has the following properties: (a) $E[Z(t)] = 0$, (b) $E[Z(t), Z(t)] = \text{VARIANCE}(Z)$ and (c) $E[Z(t), Z(t-s)] = 0$, for all s . $E[\]$ is the expectations operator.

[31] For a further discussion of stationarity, see Chatfield (1975) or Pindyck and Rubinfeld (1976).

[32] The IDA package program for time series analysis was used to compute the necessary information and estimate the selected models.

[33] With $c(k) = \frac{1}{N-k} \sum_{t=1}^{N-k} (X(t) - E[X]) * (X(t-k) - E[X]) / N$, the estimated autocovariance function, and $c(0)$, the estimated variance, the normalization of $c(k)$ is the estimated autocorrelation function $r(k)$, $r(k) = c(k)/c(0)$, $k = 1, 2, \dots$ and N = the number of observations.

[34] $RMSE = \sqrt{[(1/n) * \sum_{i=1}^n (F(i) - A(i))^2]}$, where $i = 1, 2, \dots, n$, n = number of forecasts, $F(i)$ = forecast and $A(i)$ = actual value.

[35] Given an equation in log-linear form, $\ln Y = \ln A + B \ln X$, with B the estimated coefficient, it can be shown that B is the elasticity coefficient, $ELAST(YX)$. Proof: $ELAST(YX) = [(dY/dX) * (X/Y)] = d(\ln Y)/d(\ln X) = B$.

[36] Some of these studies are: Larsen (1947), Nowell (1948), Scofield (1957) and (1965), Tweeten and Martin (1966), Herdt and Cochrane (1966), Reynolds and Timmons (1969), Klinefelter (1973), and Kuhlman (1978).

[37] The standard errors for $r(k)$ are computed as: $S.E.[r(k)] = 1/(\text{square root}(N))$, where k = the order of the autocorrelation and N = the number of observations.

[38] See Mills (1977) or Theil (1966) for a further discussion of this point and accuracy analysis in general.

[39] See Mills (1977).

[40] The term "complex" is meant to mean models containing superfluous variables or an intricate model where a basic structural model would be sufficient. See Mills (1977) for a discussion of the variance proportion, $U(s)$.

[41] Studies of note in the area of comparing ARIMA and econometric model forecasts are Nelson (1972) and Naylor, et. al. (1972). Granger (1980) also discusses the comparison.

[42] Exceptions do exist, for example Klinefelter (1972) and Chavas and Shumway (1981).

[43] For a discussion and application of vector-autoregression, see Sims (1980). Some information concerning state-space forecasting, particularly about the automatic identification criterion, can be obtained in Akaike (1976).

[44] An extensive source of information concerning rational expectations models and theory may be found in Lucas and Sargent (1981).

BIBLIOGRAPHY

SELECTED BIBLIOGRAPHY

- Akaike, H. "Canonical Correlation Analysis of Time Series and the use of an Information Criterion." System Identification: Advances and Case Studies. Ed. Mehra, R. and Lainiotis, D. New York: Academic Press, 1976.
- Bhatia, Kul B. "On Estimating Capital Gains in U.S. Agriculture." American Journal of Agricultural Economics 53 (1971): 502-506.
- Bhatia, Kul B. "Capital Gains and the Aggregate Consumption Function." American Economic Review 62 (1972): 866-889.
- Boles, Donald E., and Rupnow, Gary I. "Local Governmental Functions Affected by the Growth of Corporate Agricultural Land Ownership: A Bibliographical Review." The Western Political Quarterly 32 (1979): 467-478.
- Box, G.E.P., and Jenkins, G.M. Time Series Analysis: Forecasting and Control. San Francisco: Holden-Day, 1970.
- Brake, John R., and Melichar, Emanuel. "Agricultural Finance and Capital Markets." A Survey of Agricultural Economics Literature-Vol. 1. Ed. Lee R. Martin: 411-494. Minneapolis: University of Minnesota Press, 1977.
- Brandow, G.E. "Policy for Commercial Agriculture, 1945-71." A Survey of Agricultural Economics Literature, Vol. 1, Ed. Lee R. Martin: 209-292. Minneapolis: University of Minnesota Press, 1977.
- Carter, Harold O., and Johnston, Warren E. "Some Forces Affecting the Changing Structure, Organization, and Control of American Agriculture." American Journal of Agricultural Economics 60 (1978): 738-747.
- Chatfield, C. The Analysis of Time Series: Theory and Practice. New York: J. Wiley and Sons, 1975.
- Chavas, Jean-Paul, and Shumway, Richard C. "A Pooled

Time-Series, Cross-Section Analysis of Land Prices." Texas A and M University, Department of Agricultural Economics, 1981. (Unpublished Mimeograph).

Chiang, Alpha C. Fundamental Methods of Mathematical Economics. 2nd Edition, New York: McGraw-Hill Co., 1974.

Chryst, Walter E. "Land Values and Agricultural Income: A Paradox?" Journal of Farm Economics 47 (1965): 1265-1277.

Committee on Agriculture, Nutrition, and Forestry, U.S. Senate. Agricultural Land Availability. Washington, D.C.: U.S. Government Printing Office, 1981.

Economic Report of the President, Washington, D.C.: U.S. Government Printing Office, January, 1981.

Federal Reserve Bank of New York. Federal Reserve Bulletin. December, 1980.

Feldstein, M. "Inflation, Portfolio Choice, and the Price of Land and Corporate Stock." Cambridge, Mass.: National Bureau of Economic Research Work. Paper 526, August, 1980.

Gilliam, Henry C., Jr., and Hubbard, J.W. "Analysis of Agricultural Land Values in Selected Cotton Producing Counties of the South Carolina Coastal Plains." Department of Agricultural Economics and Rural Sociology, Agricultural Experiment Station Bulletin 554, Clemson University, Clemson, South Carolina, 1971.

Granger, C.W.J. Forecasting in Business and Economics. New York: Academic Press, 1980.

Hall, Brownyn H., and Hall, Robert E. Time Series Processor, Version 3.5 User's Manual for DEC 10 Computers. 1981.

Hammill, A.E. "Variables Related to Farm Real Estate Values in Minnesota Counties." Agricultural Economic Research 21 (1969): 45-50.

Healy, Robert G. and Short, James L. "New Forces in the Market for Rural Land." The Appraisal Journal. 46 (1978): 185-189.

Herdt, R.W. and Cechrane, W.W. "Farmland Prices and Technological Advance." Journal of Farm Economics 48 (1966): 243-263.

Internal Revenue Service. "Special Use Valuation." Internal Revenue Code § 2032a.

- Intrilligator, Michael D. Econometric Models and Applications. Englewood Cliffs, N.J.: Prentice-Hall, Inc., 1978.
- Klinefelter, Danny A., "Factors Affecting Farmland Values in Illinois." Illinois Agricultural Economics 13 (1973): 27-33.
- Klinefelter, Danny A.; Penson, John B. Jr.; and Fraser, Donald R. "Effects of Inflation on Financial Markets and Agricultural Lending Institutions." American Journal of Agricultural Economics 62 (1980): 1054-1059.
- Kost, W. E. "Rates of Return for Farm Real Estate and Common Stock." American Journal of Agricultural Economics 50 (1968): 213-224.
- Kuhlman, Richard H. "An Econometric Study of Factors Affecting Farmland Prices, 1940-1977." M.S. Thesis, Oklahoma State University, 1978.
- Larsen, H. C. "Relationship of Land Values to Warranted Values 1910-48." Journal of Farm Economics 30 (1948): 579-588.
- Lins, David A., and Duncan, Marvin. "Inflation Effects of Financial Performance and Structure of the Farm Sector." American Journal of Agricultural Economics 62 (1980): 1049-1053.
- Lucas, R. E., Jr.; and Sargent, T. J. Rational Expectations and Economic Practice. Minneapolis: University of Minnesota Press, 1981.
- Luttrell, Clifton B. "The 'Danger' From Foreign Ownership of U.S. Farmland." Federal Reserve Bank of St. Louis Review 61 (1979): 2-9.
- Luttrell, Clifton B. "Rising Farm Exports and International Trade Policies." Federal Reserve Bank of St. Louis Review 61 (1979).
- Melichar, Emmanuel. "Some Current Aspects of Agricultural Finance and Banking in the United States." American Journal of Agricultural Economics 59 (1977): 967-972.
- Melichar, Emanuel. "Capital Gains Versus Current Income in the Farming Sector." American Journal of Agricultural Economics 61 (1979): 1085-1092.
- Mills, Richard L. Statistics For Applied Economics and Business. New York: McGraw-Hill, Inc., 1977.

- Morris, Douglas E. "Farmland Values and Urbanization." Agricultural Economics Research 30 (1978): 44-47.
- Morris, Douglas E., and Lindsay, Bruce E. "Population and Farmland Values in the Northeast." Journal of the Northeastern Agricultural Economics Council 6 (1977): 106-116.
- Murray, Ray A., and Reinsel, R.D. The Transfer of Farm and Open Country Real Estate in Six Maryland Counties, 1962. Misc. Publication 557. College Park, Maryland: Maryland Agricultural Experiment Station, [Jure, 1965].
- Naylor, T.H.; Seaks, T.G.; and Wichern, D.W. "Box-Jenkins Methods: An Alternative to Econometric Models." International Statistical Review 40 (1972).
- Nelson, C.R. "The Predictive Performance of the FRB-MIT-PENN Model of the U.S. Economy." American Economic Review 62 (1972).
- Nowell, R.I. "The Farm Land Boom." Journal of Farm Economics 29 (1947): 130-149.
- Pasour, E.C., Jr. "Real Property Taxes and Farm Real Estate Value: Incidence and Implications." American Journal of Agricultural Economics 55 (1973): 549-556.
- Pasour, E.C., Jr. "The Capitalization of Real Property Taxes Levied on Farm Real Estate." American Journal of Agricultural Economics 57 (1975): 539-547.
- Pindyck, R.S. and Rubinfeld, D.L. Econometric Models and Economic Forecasts. New York: McGraw-Hill, Inc., 1976.
- Plaxico, James S. "Implications of Divergence in Sources of Returns in Agriculture." American Journal of Agricultural Economics 61 (1979): 1098-1102.
- Plaxico, James S., and Kletke, Darrel D. "The Value of Unrealized Farm Land Capital Gains." American Journal of Agricultural Economics 61 (1979): 327-330.
- "Plowed Under: Go-Go Young Farmer Who Rode Prices Up is Laid Low by Dekt." The Wall Street Journal, 11 March, 1982, p. 1, 16.
- Pope, R.P.; Kramer, R.A.; Green, R.D.; and Gardner, B.D. "An Evaluation of Econometric Models of U.S. Farmland Prices." Western Journal of Agricultural Economics 4 (1979): 107-119.

Reinsel, R.D. "The Aggregate Real Estate Market: An Evaluation of Prevailing Hypotheses Explaining the Time Series Trend in the United States Average Farm Real Estate Values." Ph.D. Dissertation, Michigan State University, 1973.

Reinsel, R.D.; and Krentz, R.D. Capitalization of Farm Program Benefits into Land Values. Washington, D.C.: United States Department of Agriculture, ERS, 506, 1972.

Reinsel, R.D.; and Reinsel, Edward I. "The Economics of Asset Values and Current Income in Farming." American Journal of Agricultural Economics 61 (1979): 1093-1097.

Renshaw, E. "Are Land Prices Too High: A Note on Behavior in the Land Market." Journal of Farm Economics 39 (1957): 505-510.

Reynolds, John E. "An Econometric Investigation of Farmland Values in the United States." Ph.D. dissertation, Iowa State University, Ames, 1966.

Reynolds, T.E. and Timmons, J.F. Factors Affecting Farmland Values in the United States. Research Bulletin 566. Iowa: Iowa Agricultural Experiment Station, [1969].

Scofield, W.H. "Land Returns and Farm Income." Farm Real Estate Market Developments. United States Department of Agriculture CD-67: 44-45, August, 1965.

Scofield, W.H. "Prevailing Land Market Forces." Journal of Farm Economics 39 (1957): 1500-1510.

Scott, John T., Jr. "Factors Affecting Land Price Decline: Where To From Here?." Urbana-Champaign: University of Illinois, June 1982. (Unpublished Mimeograph).

Shalit, Haim, and Schmitz, Andrew. "Farmland Accumulation and Prices." American Journal of Agricultural Economics 64 (1982): 710-719.

Sims, C. "Macroeconomics and Reality." Econometrica 48 (1980): 1-48.

Stanton, B.F. "Perspectives on Farm Size." American Journal of Agricultural Economics. 60 (1978): 727-737.

Talbot, Ross B., ed. The World Food Problem and U.S. Food Politics and Policies: 1978, A Readings Book. Ames: The Iowa University Press, 1979.

Theil, Henri. Applied Economic Forecasting. Amsterdam:

North Holland, 1966.

Tomek, William G. "R-Squared In TSLS and GLS Estimation." American Journal of Agricultural Economics 55 (1973): 670.

Tweeten, L.G.; and Martin, J.E. "A Methodology for Predicting U.S. Farm Real Estate Price Variation." Journal of Farm Economics 48 (1966): 378-393.

U.S. Department of Agriculture, ERS, Farm Real Estate Market Developments. Washington, D.C.: U.S. Government Printing Office, various issues.

U.S. Department of Agriculture, ESCS, National Economics Division. Agricultural Statistics. Washington, D.C.: U.S. Government Printing Office, various years.

U.S. Department of Agriculture, ESCS, National Economics Division. Balance Sheet of the Farming Sector. Washington, D.C.: U.S. Government Printing Office, various issues.

U.S. Department of Agriculture, ESCS, National Economics Division. Economic Indicators of the Farm Sector: Income and Balance Sheet Statistics, 1979, Statistical Bulletin no. 65C. Washington, D.C.: U.S. Government Printing Office, December, 1980.

U.S. Department of Agriculture, ESCS. State Farm Income Statistics. Washington, D.C.: U.S. Government Printing Office, September, 1978.

U.S. General Accounting Office. Comptroller General's Report to the Chairmen, Sub-Committee on Family Farms, Rural Development, and Special Studies, and Sub-Committee on Domestic Marketing, Consumer Relations, and Nutrition, House Committee on Agriculture: An Assessment of Parity as a Tool for Formulating and Evaluating Agricultural Policy. Washington, D.C.: U.S. Government Printing Office, October 10, 1980.

White, F.C.; and Musser, W.N. "Inflation Effects on Farm Financial Management." American Journal of Agricultural Economics. 62 (1980): 1060-1064.

APPENDIX

APPENDIX

VARIABLE NOTATION, DATA SOURCES AND
DATA SUMMARY STATISTICSNotation, Data Description and Sources

- FP USDA index of average value per acre of U.S. farmland, 1967=100, unless indicated. Source: Farm Real Estate Market Developments, various years.
- NFI U.S. net income from farming, in millions of dollars. Source: Agricultural Statistics, various years.
- EXT The total value of receipts from foreign marketings of U.S. agricultural products, in millions of dollars. Source: Agricultural Statistics, various years.
- PAR USDA index of the ratio of the prices recieved by farmers index over the prices paid by farmers index. Source: Agricultural Statistics, various years.
- PROD The USDA index of U.S. farm output, 1967 = 100. Source: Agricultural Statistics.

GPCR The percent of total cash receipts made up by total direct government payments to farmers. Source: Agricultural Statistics, various years.

SUB Total government purchases of U.S. farm output for export, in hundreds of thousands of dollars. Source: Agricultural Statistics, various years.

RCG The six period lagged average of the real percentage change in the USDA index of farmland prices. Each lag was weighted by 0.5^{*L} , where L = the length of the lag. The real percentage change was obtained by subtracting the percentage change in the GNP price deflator from the nominal percentage change in farmland prices for each year. Sources: Farm Real Estate Market Developments, various years and The Economic Report of the President, 1981.

SPSI Alternative investment returns, measured by the real Standard and Poors Stock Price index. The nominal index was deflated by the GNP price deflator to obtain the real index. $1941 - 1943 = 10$, for the nominal index. Sources: Federal Reserve Bulletin, selected years and the Economic Report of the President, 1981.

DUM Dummy variable, taking the value of 1 for the period 1974 to 1980 and 0 elsewhere in the sample.

GVTP Total direct government payments to farmers, in millions of dollars.

Summary Statistics of Data

Variable	Mean	S.Dev.	Min.Val (yr.)	Max.Val (yr.)

FP	104.3	93.8	18.9 (1941)	409.3 (1980)
NFI	15407.0	5858.9	6573.0 (1941)	33277.0 (1974)
EXT	8873.0	9660.7	669.0 (1941)	41256.0 (1980)
PAR	86.2	14.7	64.0 (1980)	115.0 (1947)
PROD	90.5	18.6	60.0 (1941)	129.0 (1979)
GVTP	1416.9	1182.6	185.0 (1949)	3961.0 (1972)
SUB	1229.8	492.6	112.5 (1952)	2618.1 (1944)
GPCR	3.025	2.190	0.600 (1949)	7.400 (1969)
SPSI	95.78	45.07	33.8 (1942)	174.0 (1966)
RCG	0.034	0.026	0.003 (1942)	0.101 (1974)
DUM	0.175	0.379	0.000 (1941)	1.000 (1980)

Sample Period: 1941 to 1980.

Data-

YEAR	FP	SPSI	RCG	PAR	PROD	GPCR
1941	18.93	43.6	0.012	93.00	60.00	4.10
1942	20.62	33.8	0.003	105.00	68.00	3.70
1943	22.60	36.0	0.012	113.00	66.00	2.90
1944	25.71	41.4	0.061	108.00	69.00	3.40
1945	28.53	45.4	0.073	109.00	68.00	3.20
1946	32.20	56.2	0.024	113.00	69.00	2.80
1947	36.16	42.3	0.008	115.00	67.00	0.90
1948	38.98	37.8	0.009	110.00	73.00	0.80
1949	40.68	38.4	0.029	100.00	71.00	0.60
1950	39.83	42.6	0.005	101.00	70.00	0.90
1951	46.05	49.2	0.036	107.00	73.00	0.80
1952	50.56	55.7	0.061	100.00	75.00	0.80
1953	51.41	58.0	0.031	92.00	76.00	0.60
1954	50.85	54.9	0.005	89.00	79.00	0.80
1955	52.82	76.2	0.012	84.00	81.00	0.70
1956	54.80	90.0	0.011	83.00	82.00	1.70
1957	58.19	97.6	0.192	82.00	81.00	3.10
1958	61.30	86.1	0.023	85.00	86.00	3.00
1959	65.82	115.9	0.036	81.00	87.00	1.90
1960	68.36	118.6	0.028	80.00	90.00	2.00
1961	69.49	120.8	0.019	79.00	91.00	3.90
1962	73.16	138.4	0.024	80.00	92.00	4.50
1963	76.84	128.9	0.026	78.00	95.00	4.30
1964	81.92	149.4	0.037	76.00	94.00	5.50
1965	86.44	165.5	0.034	77.00	97.00	6.10
1966	93.22	174.0	0.042	79.00	96.00	6.90
1967	100.00	153.3	0.040	73.00	100.00	6.60
1968	106.78	165.5	0.034	73.00	102.00	7.20
1969	112.71	168.5	0.022	73.00	102.00	7.40
1970	117.23	140.8	0.006	72.00	101.00	6.90
1971	122.32	139.9	0.004	69.00	110.00	5.50
1972	121.19	149.7	0.004	74.00	110.00	6.10
1973	149.72	161.5	0.065	91.00	112.00	2.80
1974	186.72	118.0	0.101	86.00	106.00	0.60
1975	212.43	81.7	0.073	76.00	114.00	0.90
1976	241.53	103.2	0.078	71.00	117.00	0.80
1977	282.49	103.8	0.088	67.00	119.00	1.80
1978	308.19	83.8	0.054	70.00	122.00	2.60
1979	354.24	83.2	0.057	71.00	129.00	1.00
1980	409.32	81.5	0.059	64.00	122.00	0.90

Data-

YEAR	NFI	EXT	SUB	GVTP	DUM
1941	6573.0	669.0	792.0	544.0	0.0
1942	9924.0	1179.0	1137.8	650.0	0.0
1943	11822.0	2073.0	1988.3	645.0	0.0
1944	11807.0	2096.0	2618.1	776.0	0.0
1945	12411.0	2254.0	2011.6	742.0	0.0
1946	15252.0	3140.0	1710.0	772.0	0.0
1947	15544.0	3957.0	1559.0	314.0	0.0
1948	17789.0	3472.0	1554.6	257.0	0.0
1949	12780.0	3578.0	753.6	185.0	0.0
1950	13648.0	2873.0	548.6	283.0	0.0
1951	15934.0	4040.0	402.3	286.0	0.0
1952	14961.0	3431.0	112.5	274.0	0.0
1953	12980.0	2847.0	211.9	213.0	0.0
1954	12373.0	3054.0	361.3	257.0	0.0
1955	11305.0	3199.0	773.5	229.0	0.0
1956	11254.0	4170.0	1005.2	553.0	0.0
1957	11085.0	4506.0	1251.9	1016.0	0.0
1958	13168.0	3855.0	1259.9	1089.0	0.0
1959	10713.0	3955.0	1304.1	682.0	0.0
1960	11470.0	4832.0	1541.4	703.0	0.0
1961	11908.0	5024.0	1660.5	1493.0	0.0
1962	12007.0	5034.0	1542.5	1747.0	0.0
1963	11697.0	5584.0	1586.2	1696.0	0.0
1964	10473.0	6348.0	1669.9	2181.0	0.0
1965	12840.0	6229.0	1388.0	2463.0	0.0
1966	13897.0	6881.0	1308.0	3277.0	0.0
1967	12292.0	6380.0	1298.0	3079.0	0.0
1968	12265.0	6303.0	1044.0	3462.0	0.0
1969	14246.0	6022.0	1036.0	3794.0	0.0
1970	14100.0	7259.0	1063.0	3717.0	0.0
1971	14570.0	7693.0	1124.0	3145.0	0.0
1972	18593.0	9401.0	1039.0	3961.0	0.0
1973	33277.0	17680.0	943.0	2607.0	0.0
1974	25781.0	21999.0	1224.0	531.0	1.0
1975	24329.0	21884.0	1123.0	807.0	1.0
1976	18679.0	22997.0	1521.0	734.0	1.0
1977	20470.0	23636.0	1549.0	1819.0	1.0
1978	27880.0	29384.0	1441.0	3030.0	1.0
1979	30800.0	34745.0	1323.0	1375.0	1.0
1980	23400.0	41256.0	1410.0	1286.0	1.0

